User Modeling for Location-based recommender systems

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Topics of research: user modeling, adaptive systems, intelligent user interface, semantic web and semantic web of things, assistive technologies

And you?

Outline of the day

Morning

- Adaptive systems
  - User modeling
  - Recommender systems
  - Location-based recommenders
  - Context-aware recommenders
- Inclusive smart cities
  - Technology for inclusiveness
  - Spatial support for disabilities

Outline of the day

Afternoon

- Spatial Support for Autism
    - PIUMA project
    - **EXERCISE & PRESENTATION**

Adaptive Systems

Adaptive Systems

Adaptive systems are systems that *adapt* themselves to the current, individual user.

For example:

- the system displays only a selected number of **documents** that are deemed relevant to the user
- the system displays only selected, relevant **parts of** a document
- the system provides additional **links** to external content
- only a selected number of **relevant links** is displayed
- the system **recommends** certain items or products (recommender system)

In which situations would such adaptations be useful?

Does one size fit all?

Jeff Bezos, amazon.com

If I have 3 million customers on the Web, I should have 3 million stores on the Web

Goals of adaptive systems

The general goals of adaptivity are to improve the efficiency and effectiveness of the interaction. Adaptive systems aim to make complex systems more usable, present the users with what they want to see, as well as speed up and simplify the interaction.

This includes:

- helping users to find information
- tailoring information presentation
- recommending things
- supporting collaboration

Adaptive versus Adaptable Systems

- *Adaptable* means that users can adapt system behavior themselves
- *Adaptive* means that the system adapts its own behavior on the users behalf (e.g. Amazon recommendations)

There are in-between solutions: the system suggest the user to execute a particular adaptation (remove a menu item, add a widget to the portal page, register to a particular news feed, ...)

Adaptive System: A definition

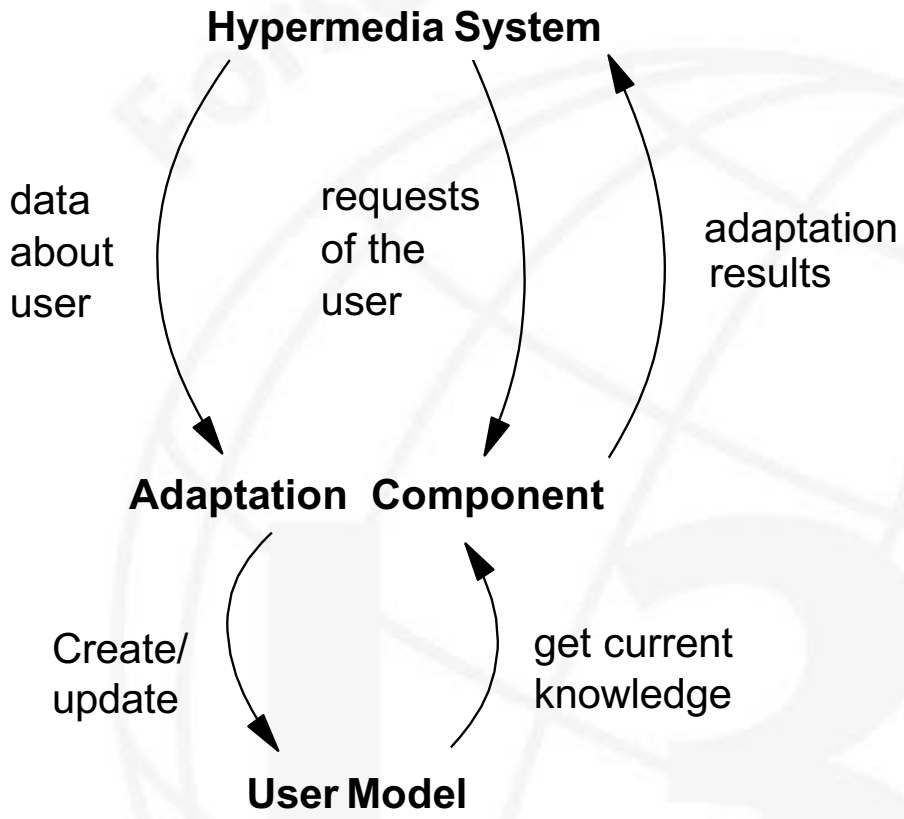
By adaptive systems we mean all (hypertext and hypermedia) systems which reflect some features of the user in a user model and apply this model to adapt various visible aspects of the system to the user.

Peter Brusilovsky: Methods and Techniques of Adaptive Hypermedia. User Modeling and User-Adapted Interaction 6 (2-3), 1996

Different voices on adaptive systems

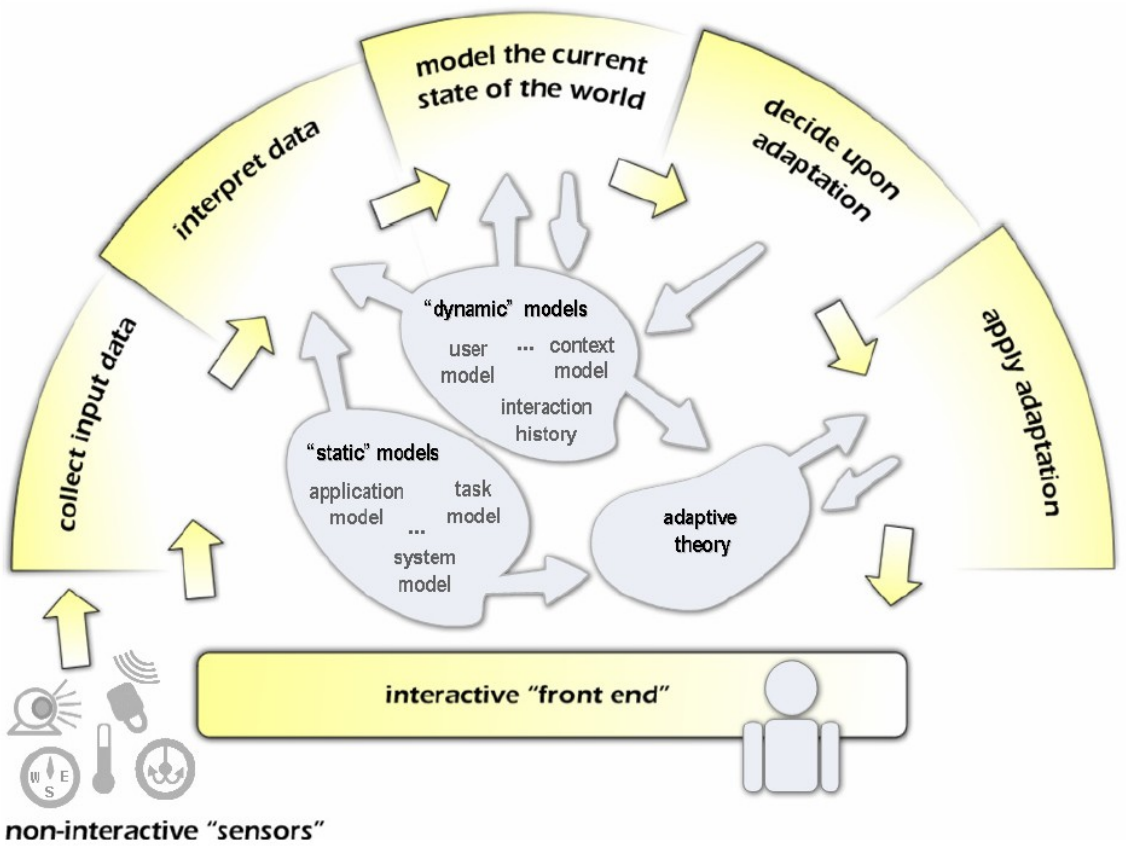
- The ambition of adaptivity is that not only 'everyone should be computer literate', but also that 'computers should be user literate' (Browne, 1990) ☺
- Personalization is a designers' approach to achieve harmony between users, tasks, environments and the system (Benyon, 1993) ☺
- Personalization is an overrated concept. Rather than investing time and energy on trying to predict individual users' needs it would be better to enhance the overall site design. (Nielsen, 1998) ☹

The adaptation: a data-oriented view



P. Brusilovsky: Methods and Techniques of Adaptive Hypermedia. User Modeling and User-Adapted Interaction 6 (2-3), 1996

The adaptation: a process-oriented view

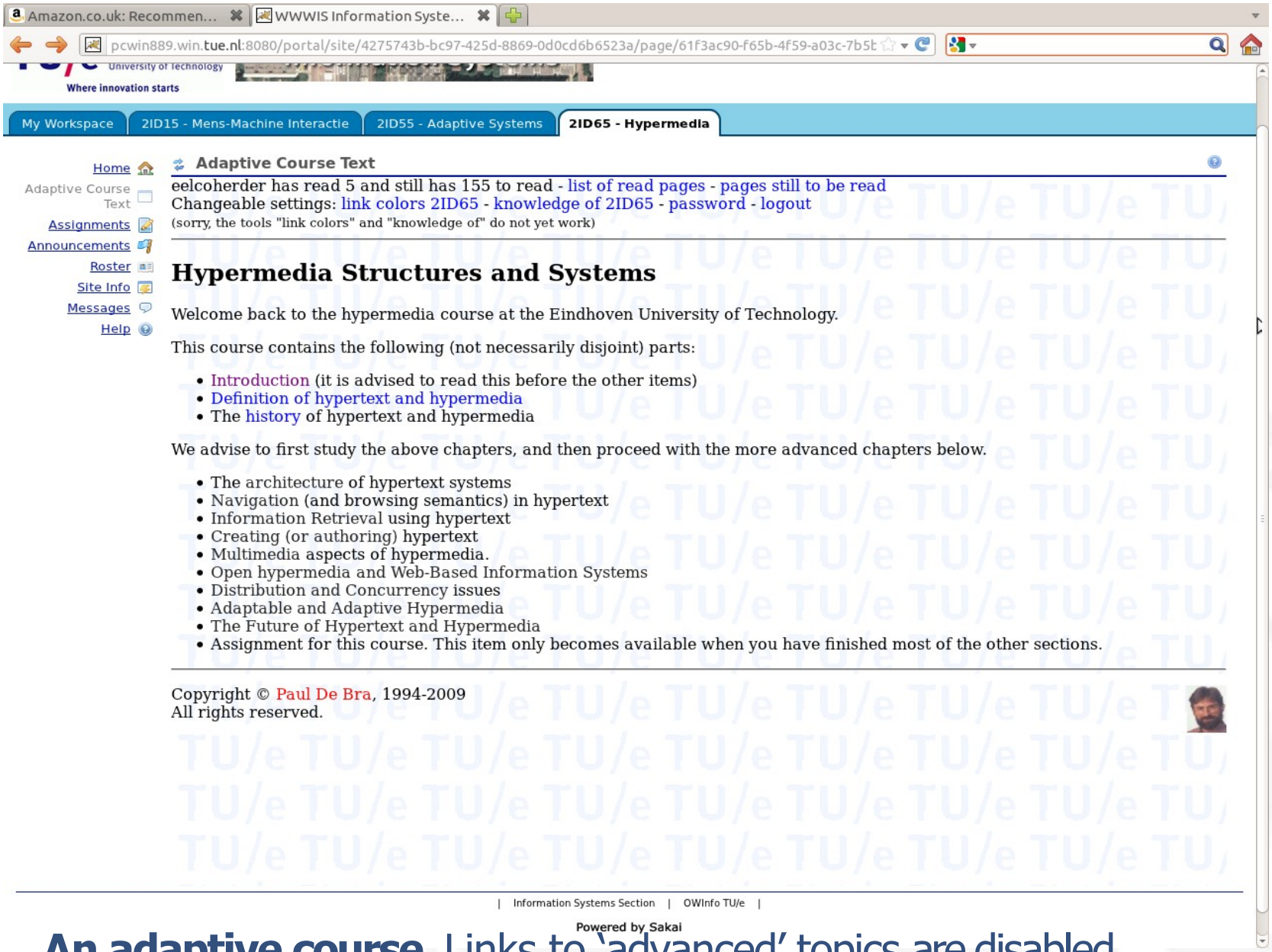


Alexandros Paramythis, Stephan Weibelzahl, Judith Masthoff. Layered evaluation of interactive adaptive systems: framework and formative methods. User Model. User-Adapt. Interact. 20(5): 383-453 (2010)

Application Areas

- *Educational hypermedia*.

  The most popular application area. User needs are well-identified: acquiring knowledge on a certain topics. User characteristics (e.g. knowledge level, interest) are well-known.



An adaptive course. Links to 'advanced' topics are disabled (made invisible) - the learner first needs to follow the introduction.

Application Areas

- *E-commerce*.

  Product recommendations and personalized offers are particularly important in the field of e-commerce → **recommender systems**

Product recommendations in Amazon. These recommendations are based on past purchases, past browsing behavior, similar users. The user can improve the recommendations by editing his or her user profile.

amazon.it

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Feedback annuncio

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Feedback sull'annuncio

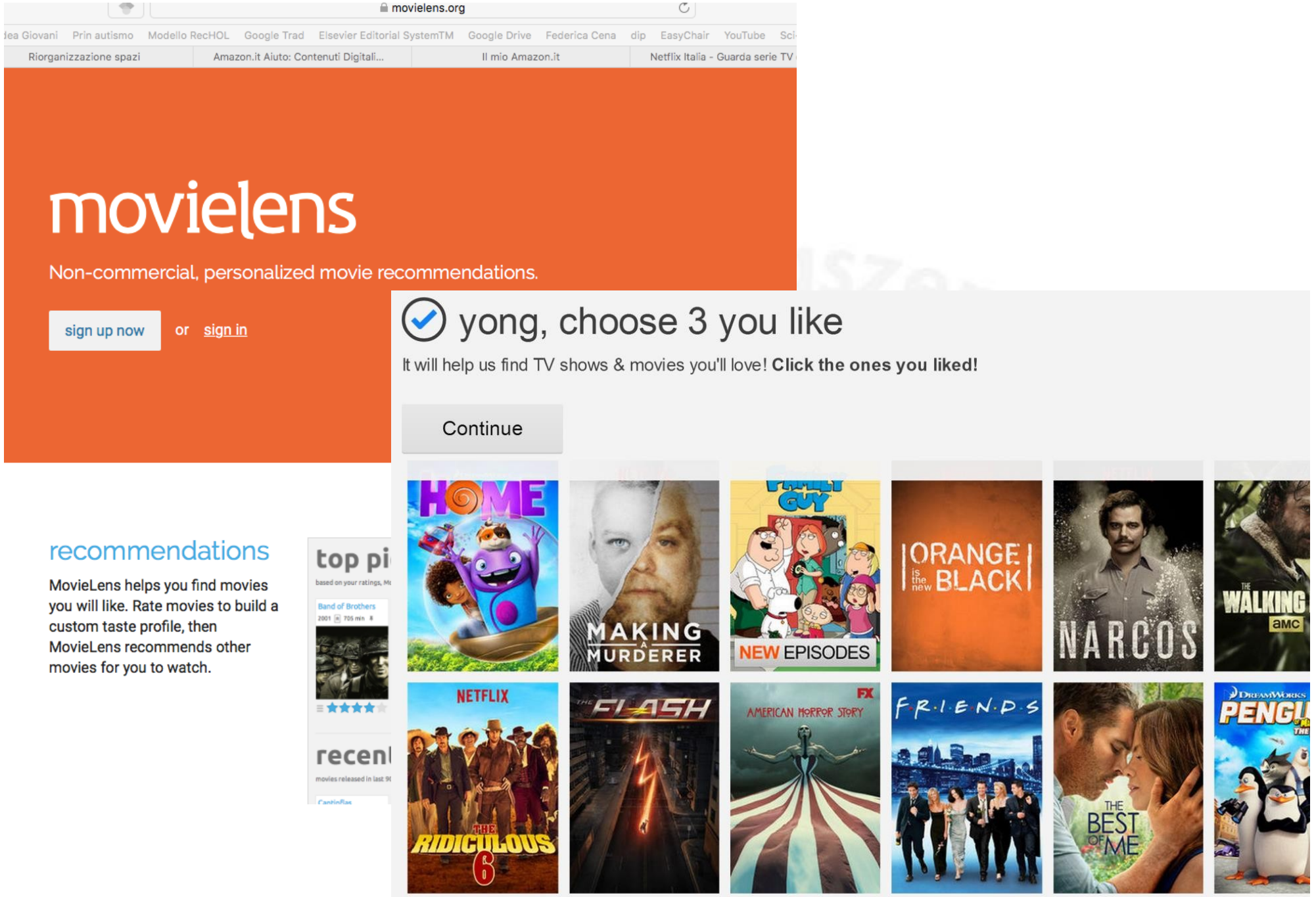
Quali altri articoli acquistano i clienti, dopo aver visualizzato questo articolo?

Application Areas

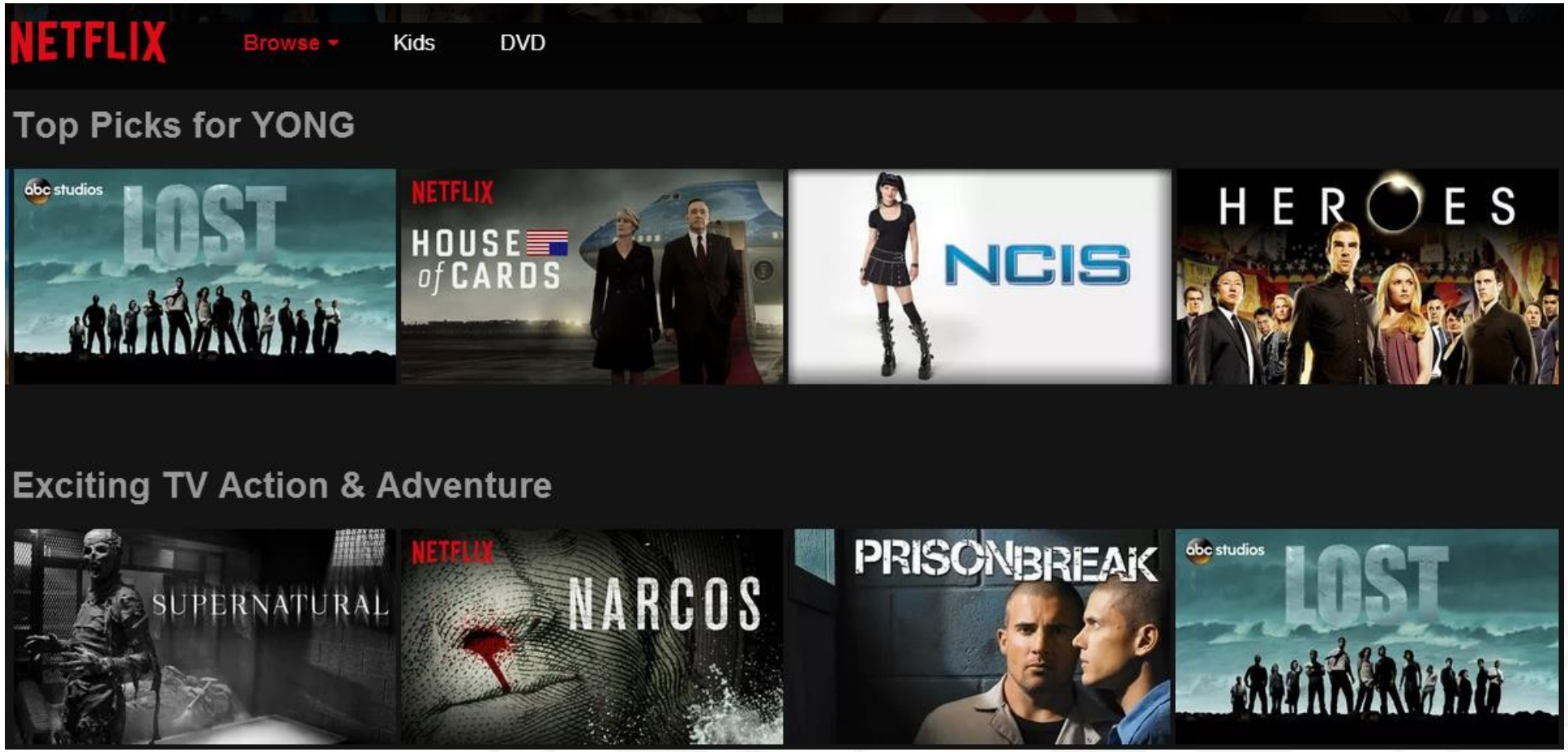
- *Online information systems* (Web sites, social media provider, social network).

  A popular adaptation technique is collaborative filtering and automated selection of content to present to the user

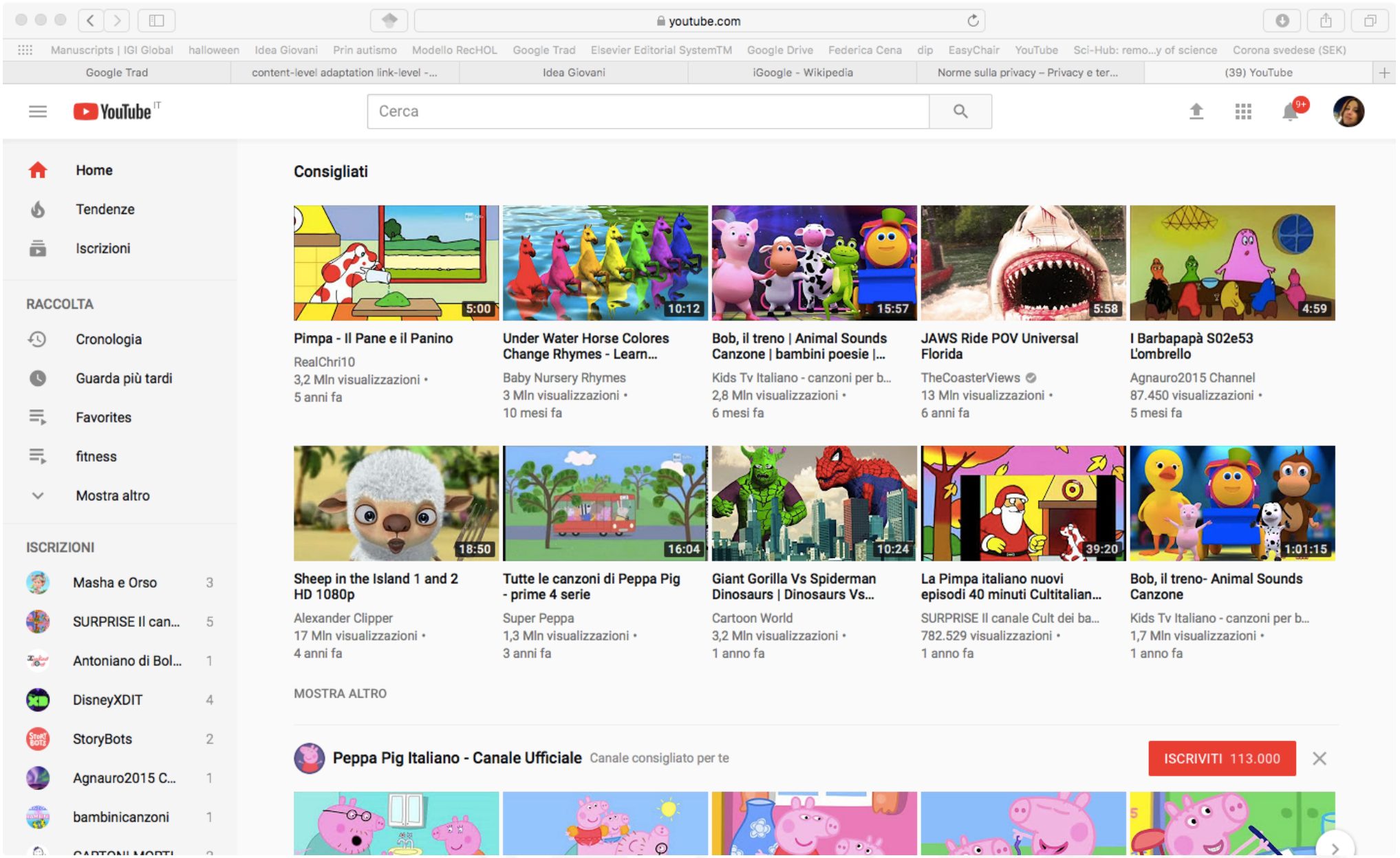
-



Movilens suggests movies based on explicit initial training of the system (telling what you like)



Netflix suggests movies based on your behaviour and similar users saw.

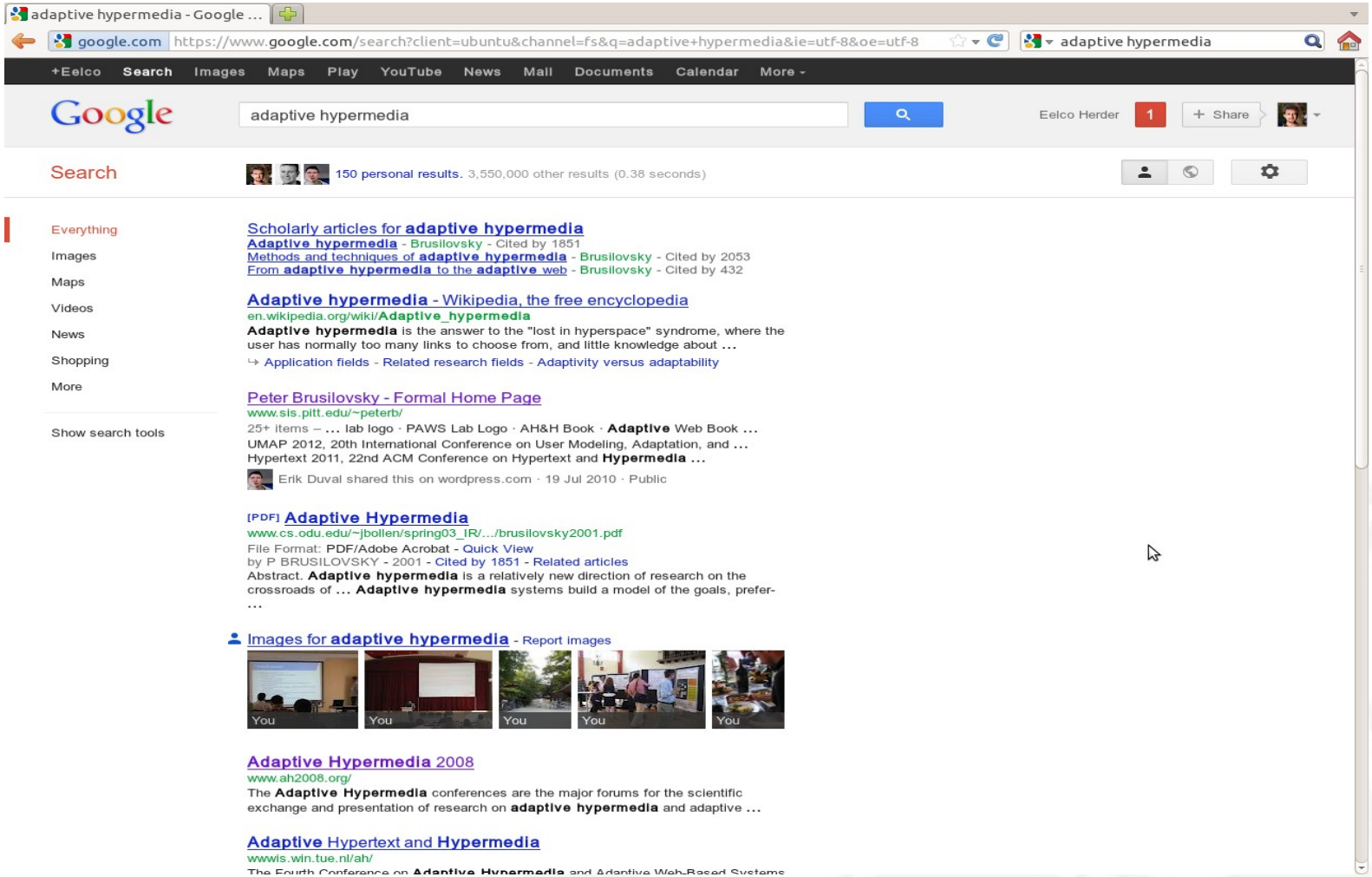


Netflix suggests movies based on your behaviour (ratings).

Facebook post selection is always personalized

› *Information retrieval*.

The filtering, sorting, categorizing or annotating of search results based on the users' search history

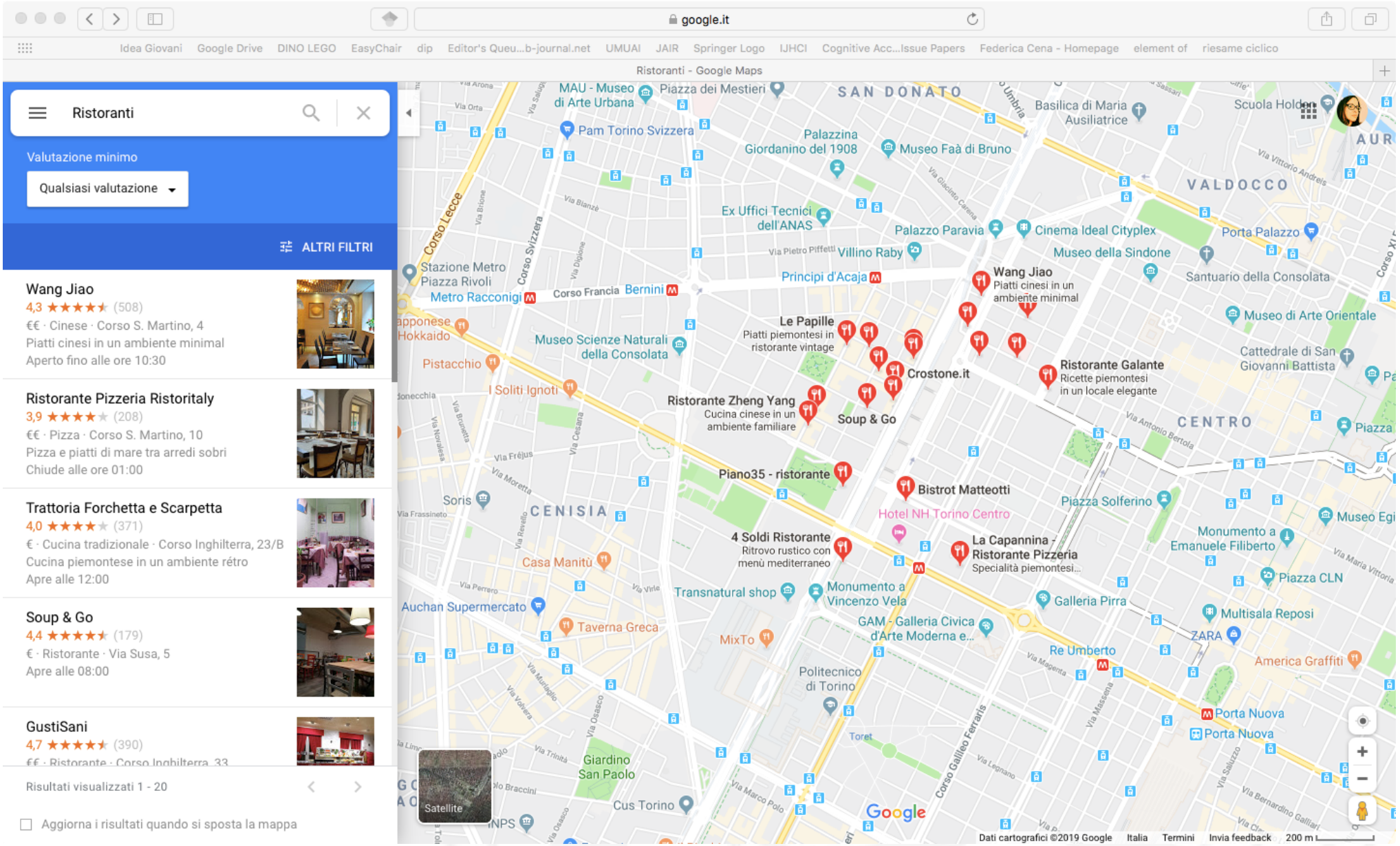


Google **search results** are personalized. Not only the 'personalized results', but the other results as well. Based on past searches, current location, language settings, etcetera.

https://policies.google.com/privacy?hl=it#infocollect

› *Contextualization and localization*.

Adaptation of the user interface to the (mobile) device, network connection speed, current location (geocode, country, language)
→ **Location-based services**



Google **maps** present places based on closeness and location history of the user

Adaptation techniques (Brusilovky 96).

- Nodes (pages) −→ **Content-level adaptation, adaptive presentation techniques**
  Select, modify, rearrange the content: Which documents to show, which parts of documents to show, order of the contents
- Edges (link) −→ **adaptive navigation support**
  to select the appropriate link to present, delete them, or generate new one. Conditional links, adaptive menus, breadcrumbs, graphical overviews, direct guidance

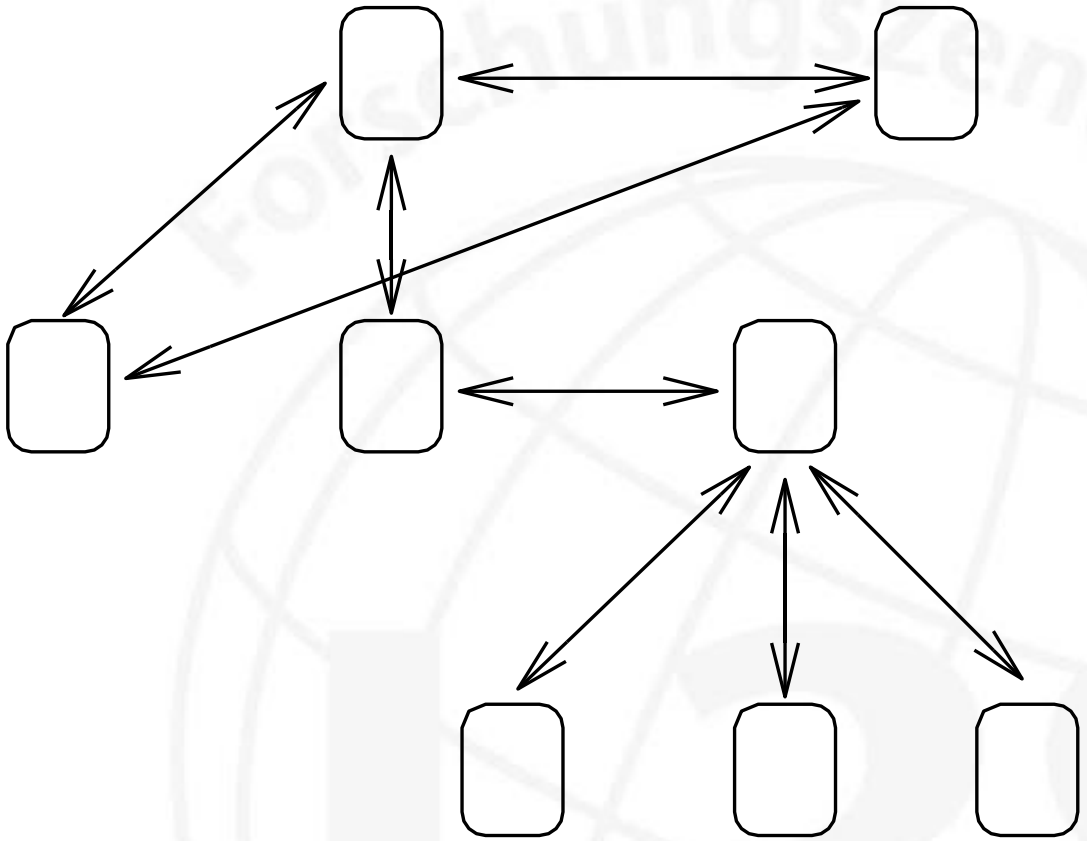


Figure:Hypertext

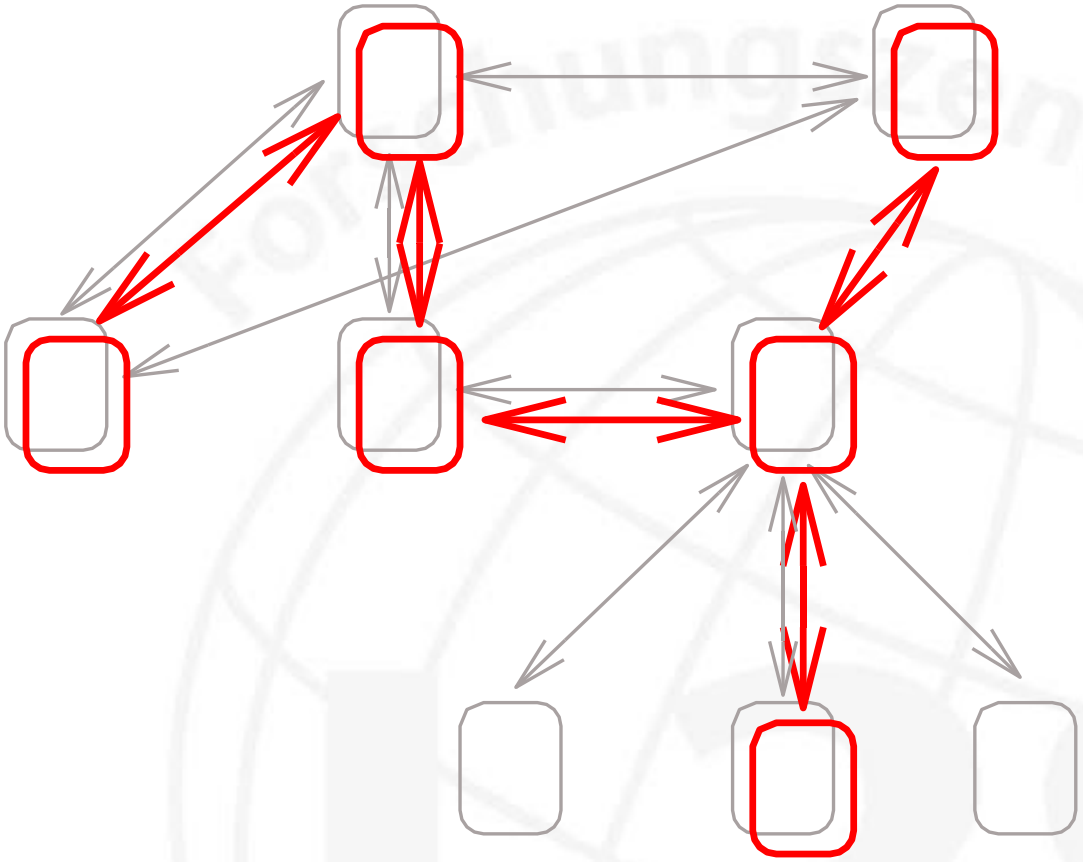


Figure:Relevant contents and links for an individual user at a specific point in time

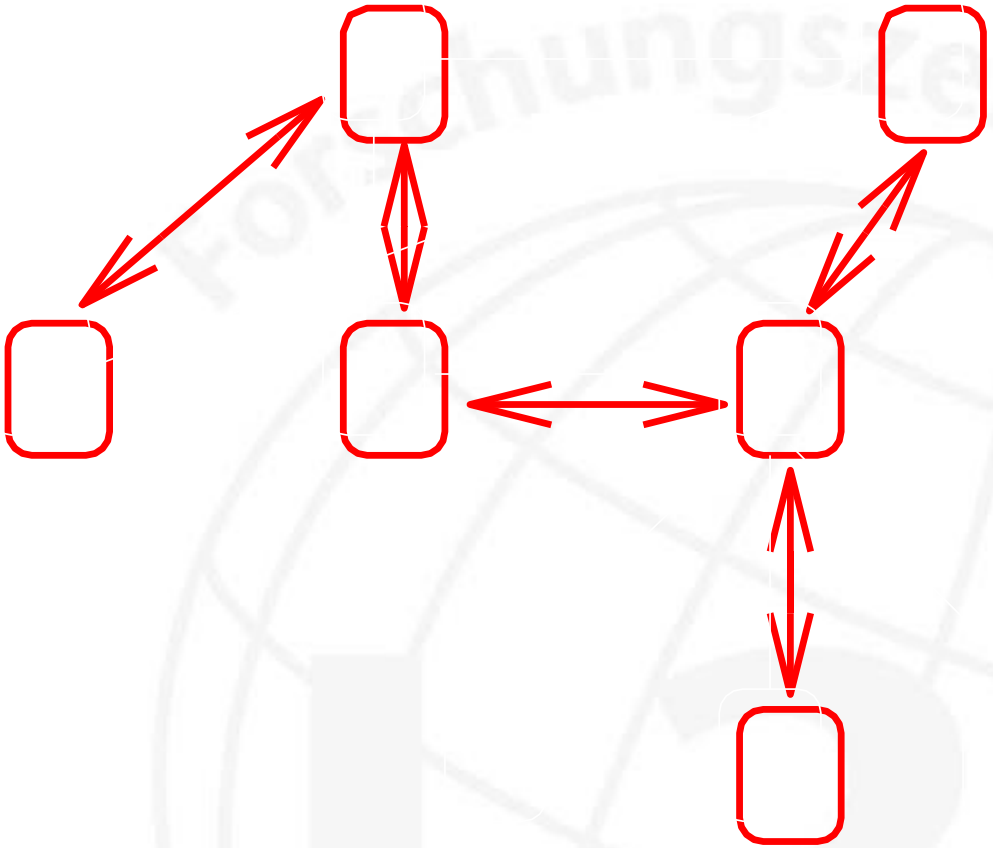
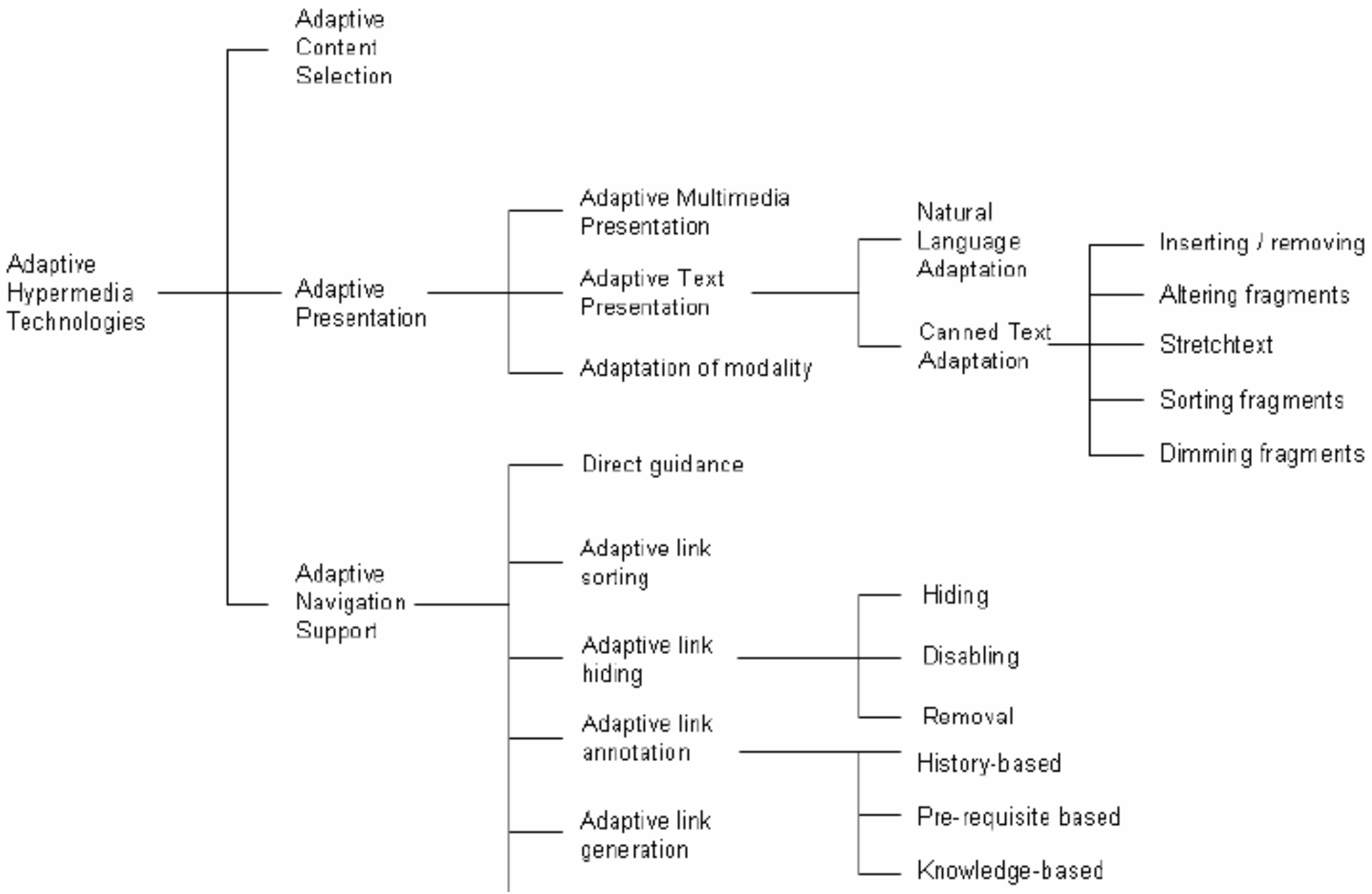


Figure:Adaptive hypertext - for an individual user at a specific point in time t)

Adaptation techniques (Kobsa, 2001)



1) Content-Level Adaptation

- 1.1.**Text adaptation.** The general goal of text adaptation is to hide some parts of information that are deemed not to be relevant for the user
- 1.2 **Content selection** (recommender systems): which objects (documents, items, product..) to present to the user (see later)

1.1 Text adaptation

Language adaptation: changing the style and complexity of the language. E.g., simplify the readability at lexical level (word substitutions) and at syntactic level (long-sentences splitting, passive-to-active transformation, etc.)

Additional text or material: explanations, introductions, definitions

- **Summary**: only the relevant or important parts are displayed
- **Comparison**: alternative (versions of) documents are displayed side to side
- **Alternative presentation**: based on user preferences, device characteristics
- Combinations of the above points

1.1 Text adaptation

- **Canned text adaptation**.conditioning the view on certain ready-made text fragments.
  - ***Conditional Text*** – text that is only displayed when certain conditions are met
  - ***Stretch text*** – text that is initially hidden or collapsed, but that can be extended by the users themselves
  - ***Page fragments / Page variants*** – Different versions of the content (e.g. easy, intermediate, advanced) that can be chosen from

2) Presentation adaptation techniques: (Kobsa et al- 2001)

The content remains the same, while the layout and the modality of representation of the content change.

- **Adaptation of modality**: text to voice, reduction of images,
- **Personalized presentation**: style sheet, background image, alternative designs

Example

- AVANTI, which selects different representation modalities based on the user's physical abilities,

3) Navigational Adaption

Disorientation or cognitive overload is addressed with adaptation of the navigation aids (menus, navigation bars, graphical overviews):

- *Direct guidance*: next page, next step, menu outline
- *Adaptive link sorting*: based on similarity, user background knowledge, relevance, ...
- *Adaptive link hiding*
- *Adaptive annotation*: color coding — traffic light metaphor: red (not recommended), yellow (suitable), green (priority)
- *Adaptive overview maps*: site maps, history visualizations

examples

- ISIS-Tutor, an educational hypermedia system, shows a limited number of links to beginner students and gradually increases them mirroring the increased student's knowledge;
- ELM-ART II , an interactive and intelligent online textbook for LISP programming, provides adaptation support by link annotation

User Modeling

WHAT IS A USER MODEL

User Modeling in Artificial Intelligence

Algorithms and methods for:

- creating digital representations of users,
- inferring knowledge about the user based on past and present interaction,
- using these models for adapting the interface or the content

Personalized systems maintain a model of the user and then use it for adapting themselves to the user. Recommender systems are the most well-known type of such systems.

User model: definition

USER MODEL (UM): a UM is a **data structure** that describes a user U in a certain moment in time.
At time t, the UM contains a snapshot of the characteristics of the user U, as collected, inferred and stored by the system S.

User data

They are are data about the user and observations about the user interaction with the system:

- that can be directly used for adaptation,
- need to be further elaborated.

Which User Data

Domain independent:

Demographic information: age, gender, profession, etc.

Contextual information: location

User goals: long and short term user objectives

User habits: user recurrent actions

User skills: abilities of the users

User traits: personality factors, cognitive factors, learning styles

User mood: happy, stressed, relaxed, tense, afraid, motivated, bored, engaged, frustrated, .

Which User data

Domain dependent

User knowledge: which concepts a user is familiar with, and which need additional explanation

User interests: in some domain concepts

Some data are easier to obtain or to infer than others (e.g., demographic data easier to obtain than traits).

Implicit vs. Explicit model

The UM can explicitly represent user features (**explicit UM**) or can be a function obtained by an inductive learning process (**implicit UM**).

Explicit user model

The user model explicitly represents the relevant aspects of the user as closely as possible (heuristics-based approach). Explicit user profile can be represented as a set of feature-value pairs or as vectors of terms.

Pros: the process is intuitive and the models are interpretable and reproducible

Cons: limitations in scalability and extendability

Implicit user model

Derived by machine learning techniques. Model-based approaches can learn a regression or classification model starting from a collection of items rated by users.

Pros: more flexible and better suitable for dealing with huge quantities of data

Cons: less human-readable

Lifetime and scope

Lifetime:

- short-term UMs that are valid for a specific session/task
- long-term UMs that store knowledge, interests, demographics etc. valid for longer time periods

Scope:

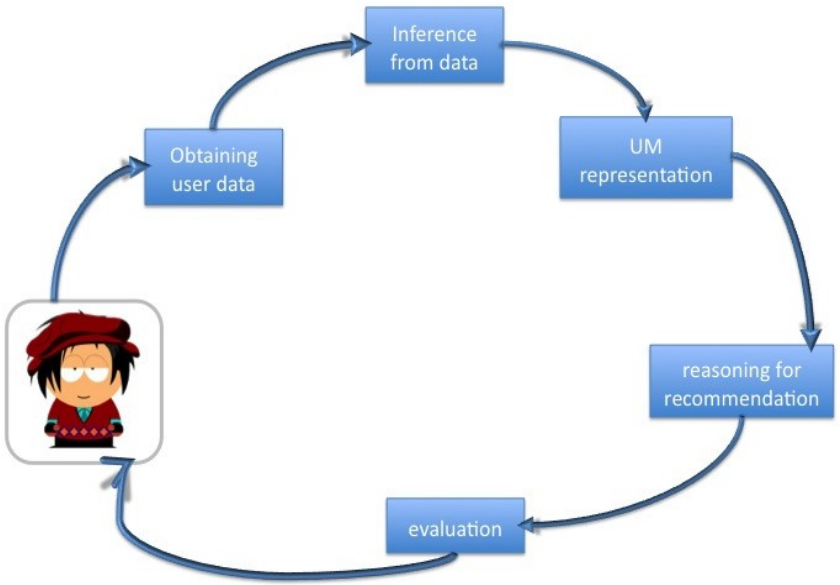
- individual UMs store information about single users
- group models represent groups of users (e.g. a class of learners)

WHAT IS USER MODELING

User Modeling: definition

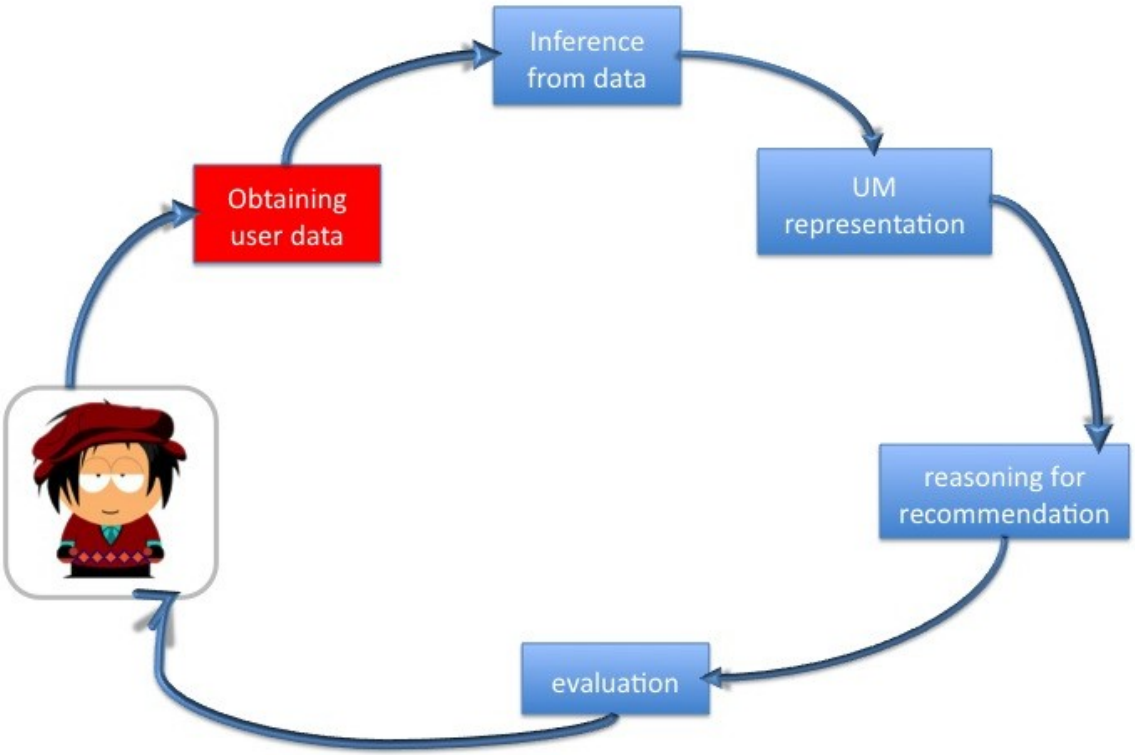
User Modeling is the process of creating and updating a user model, by deriving user characteristics from user data.

User Modeling process



- **obtaining user data** (explicit or implicit methods)
- **inferring knowledge from data** (e.g., usage pattern, classification, inference of new user features...)
- **representing UMs**, (e.g., flat, hierarchical, overlay model...)
- **reasoning on data**, (e.g., techniques for adaptation)
- **evaluating UMs**, (e.g., user centered and/or dataset-based methods)

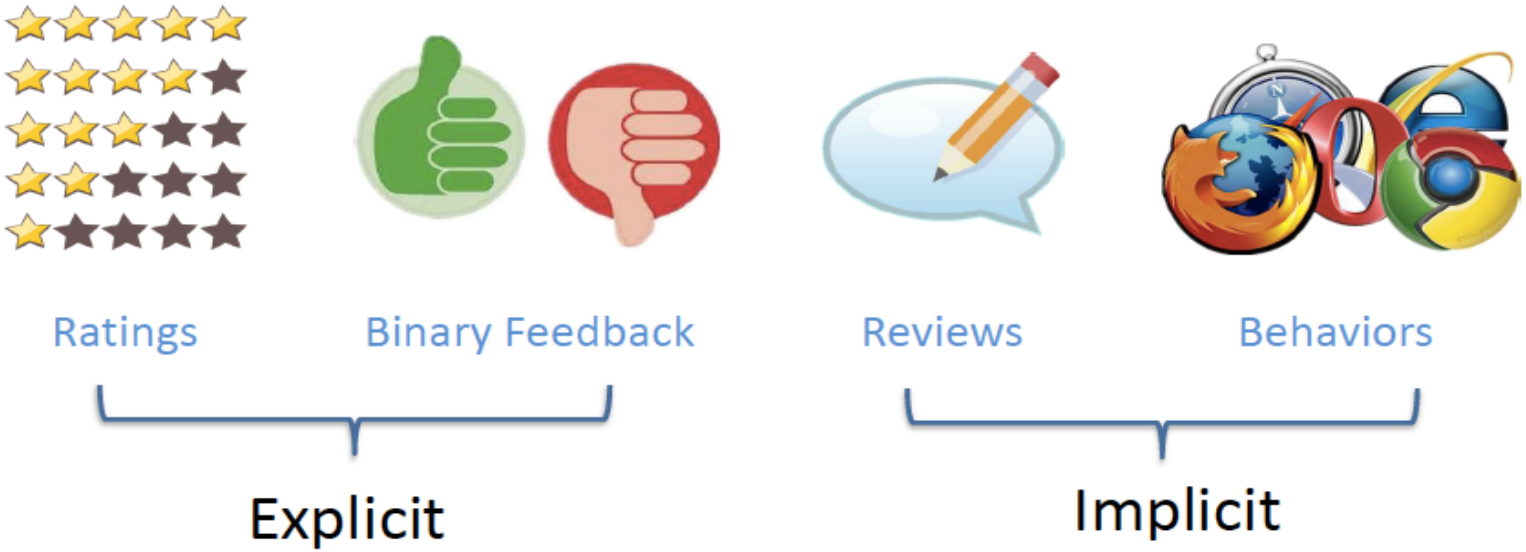
User Modeling process



Obtaining user data

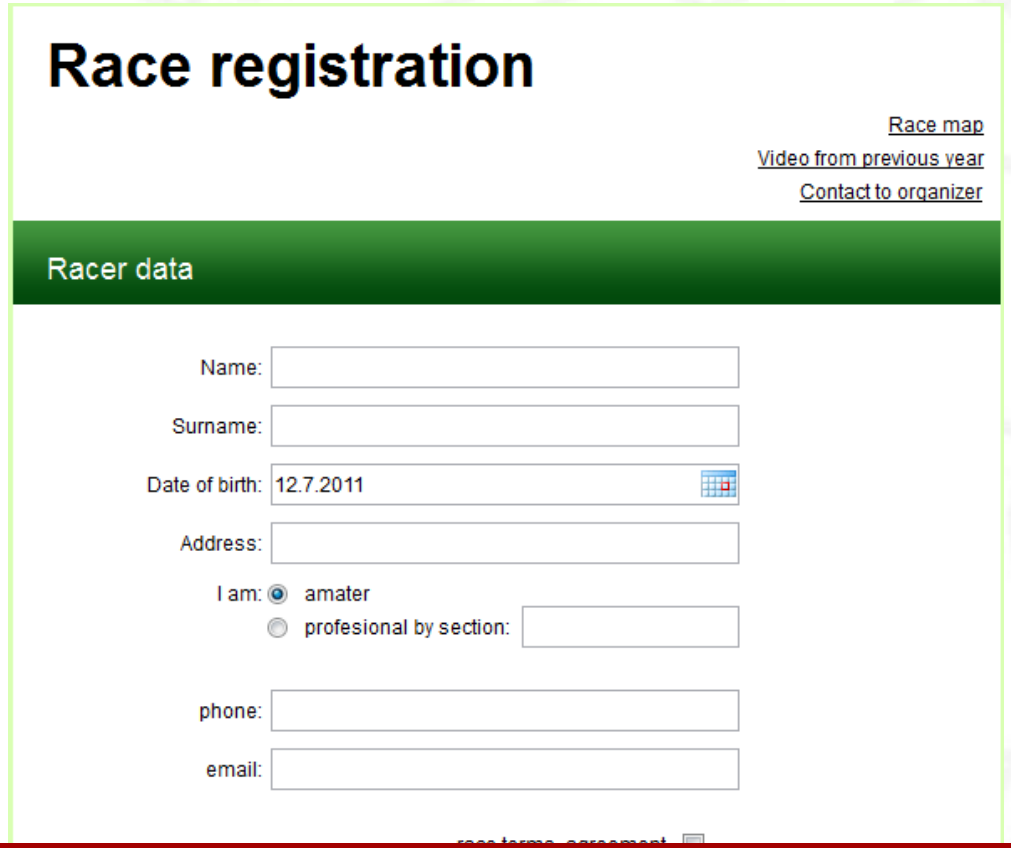
User data can be:

- explicitly provided by the user
- implicitly inferred from raw data (by observation)



Direct input from user

User input is often gathered **during the first usage** of the system using forms or questionnaires.



Direct input from user

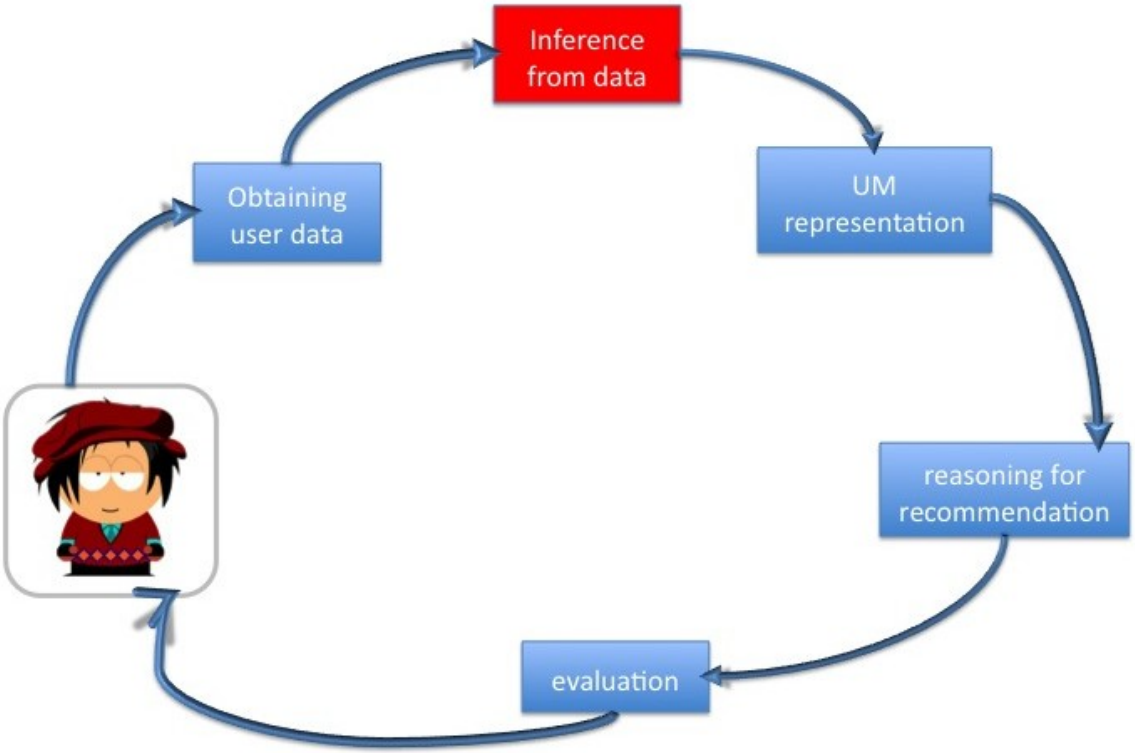
Or user input can be gathered **while the user interacts with the system**. The user can give relevance feedback by means of **rating scales**. For example, in Movielens, the recommendation process exploits user ratings of movies.

Observing the user

Users do not want to fill out forms or follow an introductory tour. Many adaptive systems try to infer knowledge directly by unobtrusively monitoring the user interactions with the system:

- browsing history (bookmark folder, search history)
- device information (display resolution, network speed and bandwidth, software)
- location (position, direction...)
- social network data (group membership...)
- Post, reviews, (sentiment analysis..)

User Modeling process



Inference from data

- **For UM creation**
- For UM update

Inference from data

The process of interpreting the observations about the user U, using conditions, rules or other forms of reasoning, and the storage of the inferred knowledge in the UM.

Many interactions contain meaning themselves, such as page visits, bookmarking or saving actions, queries issued by the user and items inspected or bought from an e-commerce Web site (no inference).

Inference from data

Other interactions need to be interpreted in order to become meaningful, such as key strokes, mouse clicks and eye gaze behavior.

Examples:

- detecting patterns in user behavior (to infer items that may be of interest for users);
- matching user behavior with the behavior of other users;
- classifying a user based on her behavior (stereotyping and the modeling of user interests).

Inference from data

By means of ad hoc algorithms es. a function that calculates the ensurance level starting from some input

Inference from data

By means of Analogic reasoning:

form of inductive argumentation for which if two or more entities are similar in one or more aspects, it is probable that they will also be in the other aspects.

Collaborative filtering, CBR, cluster

Algorithms to identify subjects or groups of subjects similar to the user, which allow us to predict the preferences of the original user.

Inference from data

By means of deductive reasoning

starting from a general knowledge to derive a particular one.

Production rules, stereotypes, semantic network, bayesian network

Inference from data

e) By means by Inductive reasonig: derive a general rule starting from a set of particular examples

CBR, decision tree, neural network

Inference from data

- For UM creation
- **For UM update**

Update of the user model

The starting user model may require some change since:

- The data can change in time
- New evidences can be gained from new sources (consistency issue)
- The model required to be corrected, especially if it is created by means of stereotypical knowledge
- It could be necessary to include other features

Update of the user model

1) It is necessary to collect **USAGE DATA about the interaction of the user with the system**
2) it is necessary to define a **strategy of updating**, i.e. to decide how to integrate the new data in the existing data structure (merge of the 2 models, rigeneration of a model, incremental learning)
    - what user actions to track
    - how to define the impact of actions on the user model
    - how much to update the model
    - when to update the user model

Inference from data

$$UpdatedModel = k1 * oldModel + k2 * newModel$$

where

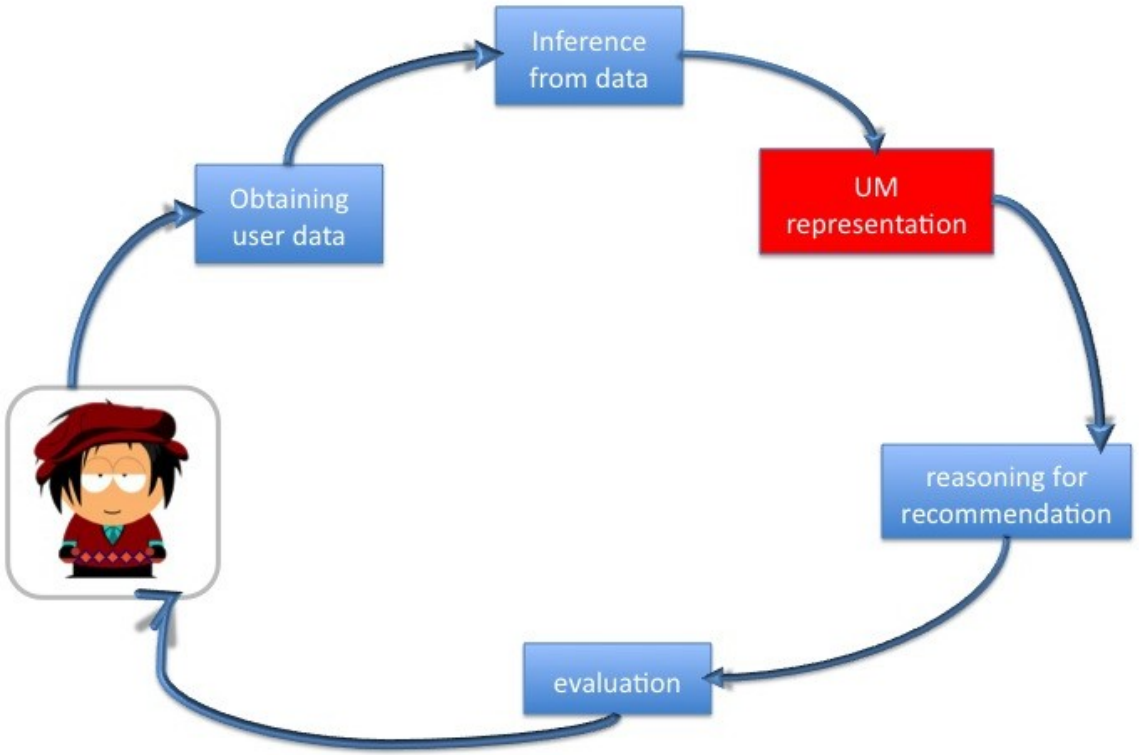
k1 + k2 = 1

at the beginning, k1 near to 0 (0.2) and k2 near to 1 (0.8)

then, k1 increases and k2 decreases (k1 0.8 k2 0.2)

At the beginning of the interaction, the present is more important, then after the past becomes more important

User Modeling process



User Model structures

A User Model is a data structure that characterizes the user U at a certain moment in time.

As seen before, UM features can be **domain independent** (user's demographics) or **domain dependent** (knowledge or preference on certain topics). The latter requires a domain representation as well.

User Model structures

It is possible to use different knowledge structure for UM, from simpler to more complex:

- Flat Models
- Hierarchical models
- Overlay models
- Stereotypes

User model representation

In each structure, domain independent and dependent user features can then be represented in any of the following ways:

- Attribute-Value Pairs
- Booleans
- Probability distributions, Fuzzy Intervals
- Vectors of terms, possibly including weights
- Logic Based representation
- Triples, semantic representations

Flat model

Attribute-value pairs: the most simple way to represent user model is a collection of variables and associated values.

An example can be:

{age, 15}
{sex, male}
{profession, student}

They may be combined as basic rules to provide adaptivity. A rule might indicate that if a user's age < 18 and user gender=female, select news items interesting to young females. It is hard to make more complex deductions.

Flat model

An example of **attribute-value with *probability distribution*** can be:

Art-Architecture/Design 0.023181
Art-Multimedia/Performances 0.013145
Art-Museums 0.001416
Cinema-Movies 0.004132

Flat model

Another example of a flat model is ***bags-of-words*** model, where using Information Retrieval techniques we construct a set of concepts which describe the user's interest. For example, in a movie domain, the following concepts describe the categories of movies that the user might be interested in:

{sport
rock
music
gym
cartoon }

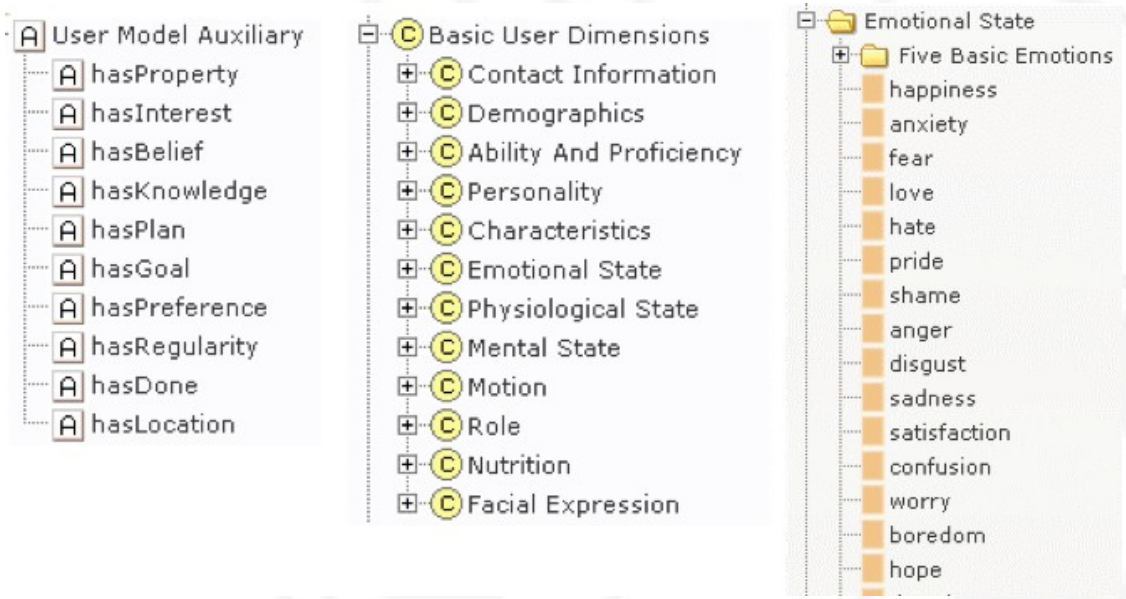
Flat model

An example of **vector space model** where items and user's profile are represented as a weighted vector computed using TF-IDF formula:

$$\begin{array}{c|cccc} & T_1 & T_2 & .... & T_t \\ D_1 & w_{11} & w_{21} & \dots & w_{t1} \\ D_2 & w_{12} & w_{22} & \dots & w_{t2} \\ : & : & : & & : \\ : & : & : & & : \\ D_n & w_{1n} & w_{2n} & \dots & w_{tn} \end{array}$$

Hierarchical model

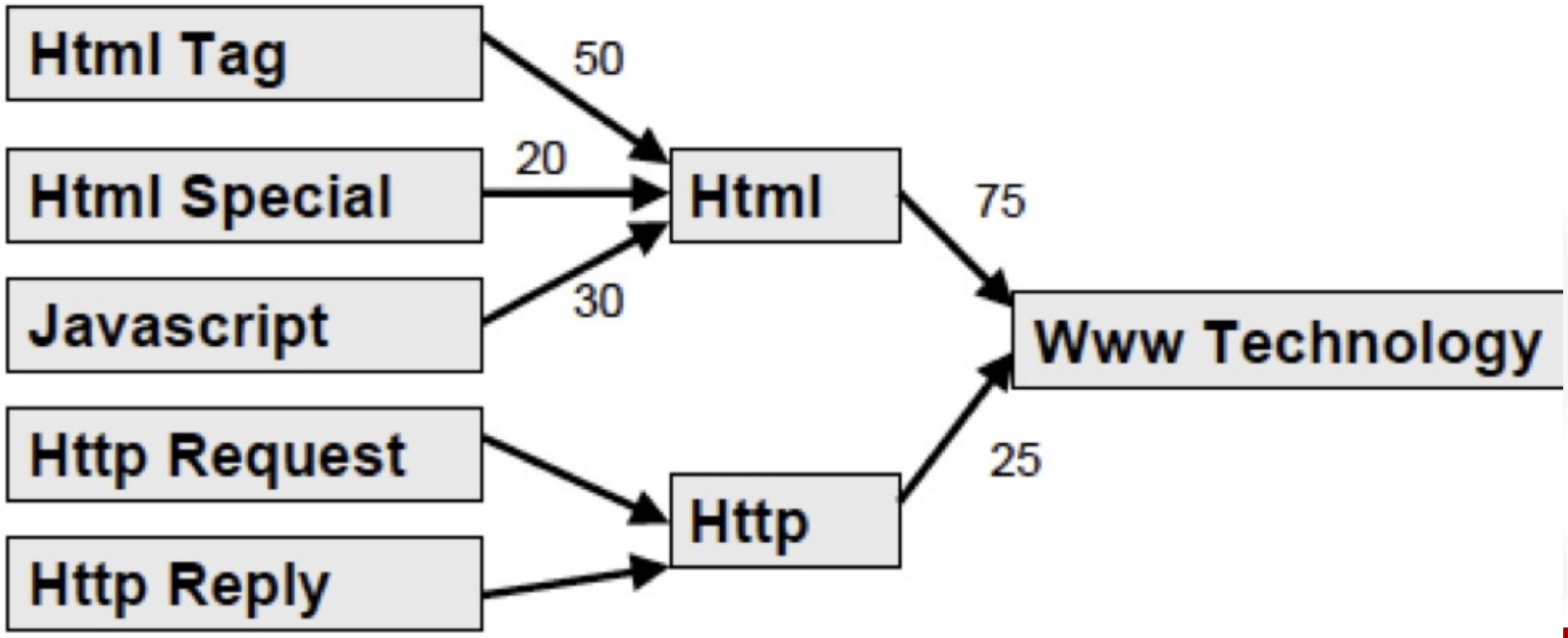
Some aspects of the UM are more general than others, relations between user characteristics. A common **hierarchical structure** is a tree or a directed acyclic graph (ontology). They are hand-crafted based on the domain knowledge of the designer.



An example of a hierarchical model for domain-independent user features

Overlay model

Domain-dependent user features (interest or knowledge) are usually represented as an overlay of the domain. For each item in the domain, the user's current state (knowledge in the example) with respect to the item is recorded.



Stereotypes

People often make assumptions about other people, often based on fairly simple observations. Stereotypes contain:

- a classification part (with domain-independent features) to classify a user in a category;
- a predictive part (with domain-dependent features) to make predictions based on the category, i.e. standard features associated.

Stereotypes

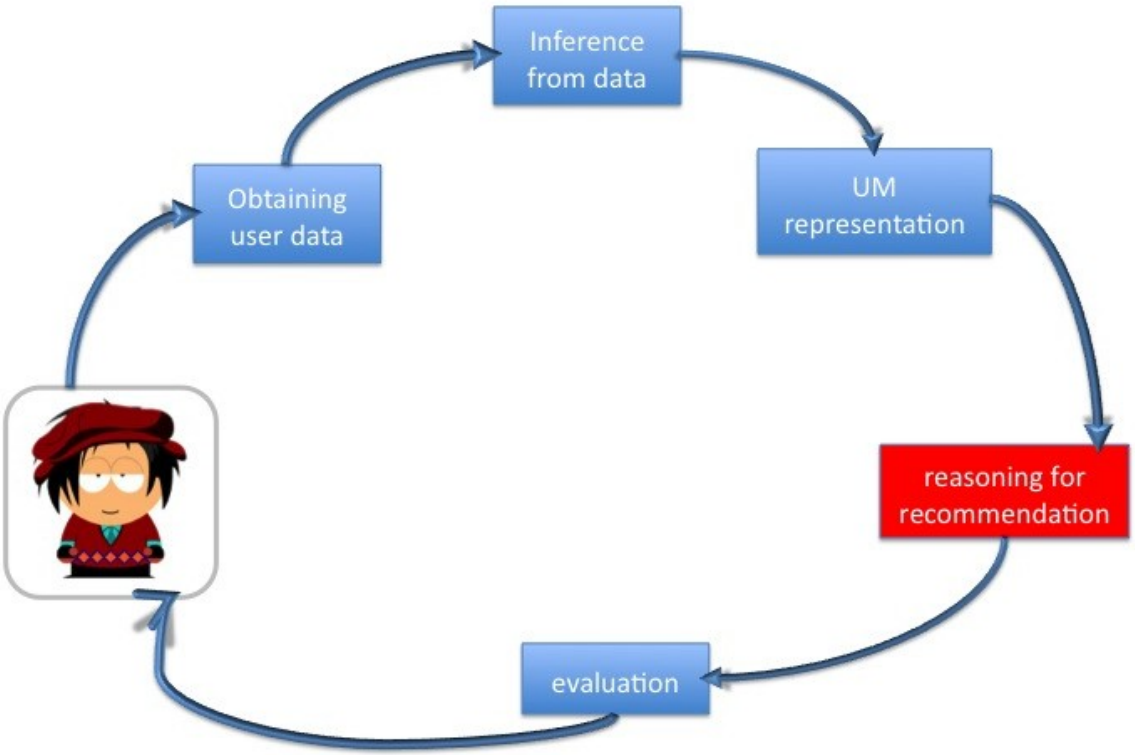
A stereotype is composed of two parts [Rich, 1989]:

a set of triggers which can apply the stereotype to the user.

a body, with information that is typically true for the member of the stereotype;

Reasoning by stereotypes means to evaluate the triggers for the specific users, and when activated, to insert in the UM the body content as assumption on user behaviour.

User Modeling process: adaptation



User Modeling process: (content) adaptation

The goal of a UM is to create a digital representation of users to be used to adapt interface and content.

In this tutorial, we focus on *content adaptation*, describing in particular the

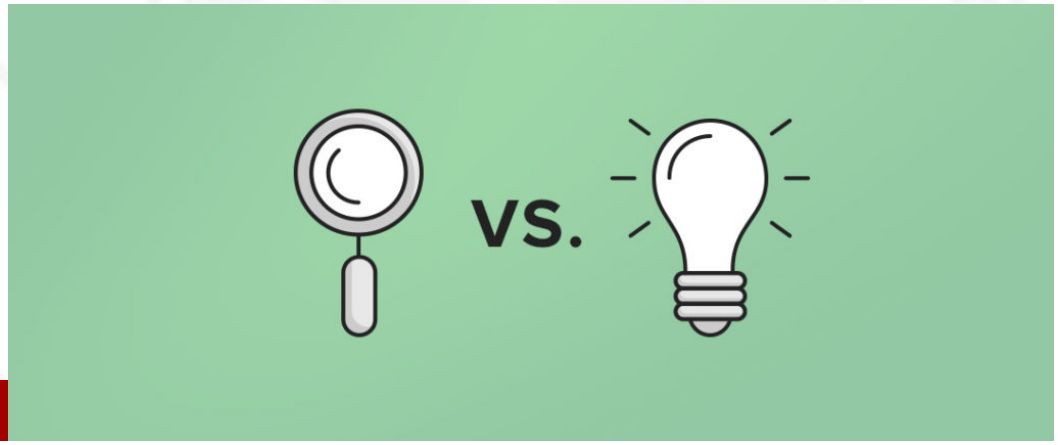
recommendation process.

Recommender systems

A family of information filtering tools providing suggestions for items.

Differently from *search systems*, they allow users to discover new resources that they may have not initially thought about.

"Search is what you do when you are looking for something. Discovery is when something wonderful that you didn't know existed finds you"



Recommender systems

The recommendation problem:

$$f : UXI \rightarrow R$$

The utility function f measures the usefulness of item $i \in I$ for user $u \in U$.

The recommendation problem consists of finding for each user U an item $i \in I$ maximizing the utility function f.

$$\forall u \in U,\ i^{max,u} = \arg\max_{i \in I} f(u, i)$$

Recommender systems

Typically, the utility of an item is represented by a rating. Only ratings for a subset of items are available.
The main task of a RS is to estimate the utility function (rating) from the available data (**predictive system**).

Prediction tasks

Rating prediction task: to accurately predict ratings (metrics: MAE, RMSE)

Top-n recommendation task: to find new specific items supposed to be the most appealing (metrics: precision, recall)

Recommender systems

Basic elements of a RS are:

Items: numeric id in a data base, or bag of keywords or set of attribute/values, or ontology based descriptions

Users: represented explicitly or implicitly depending on the approach (heuristics vs. model based)

Ratings: explicitly gathered by rating scales or implicitly inferred from user behavior.

Recommendation techniques

Main families of recommender systems:

- content-based
- collaborative filtering

on the basis of:

- the way the utility function is estimated
- the way the users and the items are represented

Content-based RSs

A description of items: attributes of movies directors)

Only the target user is considered

(source: Di Noia and Ostuni, 2015)

A CB matches up the attributes of a user profile in which preferences are stored with the attributes of an item

The basic intuition behind this approach is : since Alice likes Argo she may like Heat because they both belong to the Drama genre.

Content-based RSs

There are two main CB-RS approaches:

heuristics-based: explicit representation of user features in the model: items are recommended based on a comparison between their content and the user model

model-based: no need of explicit representation of user features in the model: first a model is created starting from examples and then used to predict unknown ratings.

Heuristics-based approach

The UM is represented using typical **Information Retrieval** techniques, for analysing the items the users liked. A typical approach is to use a **Vectors of Terms, Bags of Words** or a more sophisticated **Vector Space Model (VSM)** (where items and user profiles can be represented as a weighted vectors computed using the tf-idf formula).
The match between items and user profile can be computed using *similarity metrics* (e.g., cosine similarity) and the most similar items to the user profile are recommended.

Model-based approach

Machine Learning techniques are used to learn a model (regression or a classification) of the user preferences by analyzing the content of the items the user rated.

The training set consists of item feature vectors labeled with ratings.

Such learnt user model can be used for estimating the unknown ratings. Limitation: a large number of examples is necessary.

Training Set

Drama	Crime	class
1	0	*like*
0	1	*dislike*

Test Set

Drama	Crime	class
1	0	*?*

(source: Di Noia and Ostuni, 2015)

Limitations of content-based

content overspecialisation, i.e. the incapability of the RS to recommend relevant items different from the ones already known

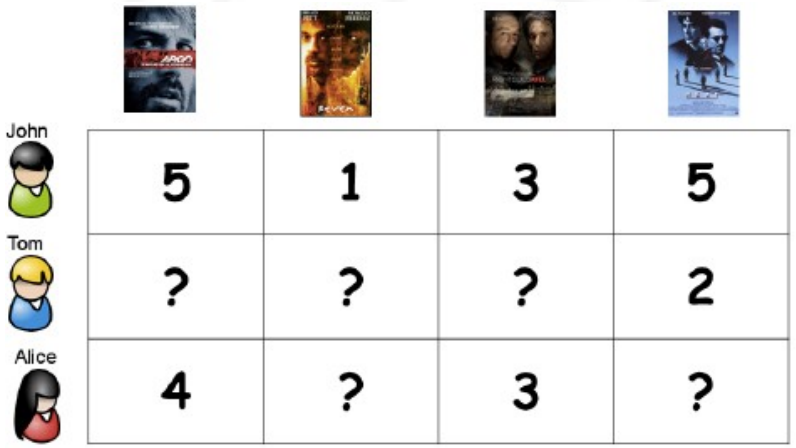
portfolio effect, i.e. redundancy and low diversity in the recommendation list

limited content analysis, i.e. the quality of CB recommendations depends on the quality of features extracted from items

Collaborative filtering

CF is the the process of filtering items using the opinions of other users having similar tastes.

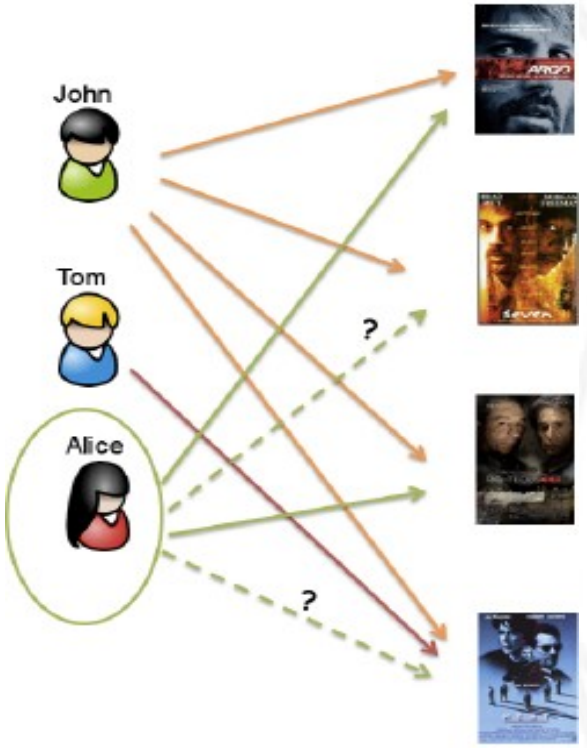
Differently from CB, the only input data that CF-RSs need is the user-item ratings matrix.



(source: Di Noia and Ostuni, 2015)

Collaborative filtering

The CF recommendation process:



Recommendations are generated considering the ratings given by other users with similar tastes. In this case, both John and Alice have similar tastes because they both rated similarly Argo and Righteous Kill. The system can exploit John's ratings for estimating Alice's unknown ratings. The basic intuition behind this method is that since John really likes Heat then also Alice may like it.

Collaborative filtering approaches

Two typologies of CF exist:

heuristics-based: based on neighborhood models (nearest neighborhood (k-NN) algorithm), which uses similarity metrics (Pearson, cosine similarity) for finding similar users and items. It does not require any preliminary model building phase.

model-based: first learn a predictive model which is used to make predictions.

Collaborative filtering: user to user

It consists of predicting the relevance of an item for the target user by a linear combination of her neighbour's ratings, weighted by the similarity between the target user and such neighbours

STEP 1: INPUT DATA

	u_1	u_2	u_3	u_4	u_5	u_6
$item_1$	5	1	5	4	0	3
$item_2$	3	3	1	1	5	1
$item_3$	0	1	0	2	1	4
$item_4$	1	1	4	1	1	2
$item_5$	3	2	5	0	0	3
$item_6$	4	3	0	0	4	0
$item_7$	0	1	5	1	1	1

Collaborative filtering

STEP 2: CALCULATE SIMILARITY

	u_1	u_2	u_3	u_4	u_5	U_6
$item_1$	5	1	5	4	0	3
$item_2$	3	3	1	1	5	1
$item_3$	0	1	?	2	1	4
$item_4$	1	1	4	1	1	2
$item_5$	3	2	5	0	0	3
$item_6$	4	3	0	0	4	0
$item_7$	0	1	5	1	1	1
Similarity measure	**0.63**	**0.56**		**0.71**	**0.22**	**0.93**

Collaborative filtering

STEP 3. DEFINE NEIGHBOURHOOD

	u_1	u_2	u_3	u_4	u_5	U_6
$item_1$	5	1	5	4	0	3
$item_2$	3	3	1	1	5	1
$item_3$	0	1	?	2	1	4
$item_4$	1	1	4	1	1	2
$item_5$	3	2	5	0	0	3
$item_6$	4	3	0	0	4	0
$item_7$	0	1	5	1	1	1

Similarity measure 0.63 0.56 0.71 0.22 0.93

Collaborative filtering

Step 3. Predictions/Recommendations

Weighted sum
$\frac{(0x0.63+2x0.71+4x0.93)}{(0.63+0.71+0.93)}$
= 2.26

			u_3	u_4	u_5	U_6
			5	4	0	3
			1	1	5	1
$item_3$	**0**	1	?	**2**	1	**4**
$item_4$	1	1	4	1	1	2
$item_5$	3	2	5	0	0	3
$item_6$	4	3	0	0	4	0
$item_7$	0	1	5	1	1	1
Similarity measure	**0.63**	**0.56**		**0.71**	**0.22**	**0.93**

Collaborative filtering: item to item

It is based on the usage of the same correlation-based or cosine-based techniques to compute similarities between items instead of users. The idea is to derive a notion of item similarity from user rating and recommend items similar to those the user has already liked.

	u_1	u_2	u_3	u_4	u_5	U_6	
$item_1$	5	1	5	4	0	3	0.62
$item_2$	3	3	1	1	5	1	0.44
$item_3$	0	1	?	2	1	4	
$item_4$	1	1	4	1	1	2	0.9
$item_5$	3	2	5	0	0	3	0.64
$item_6$	4	3	0	0	4	0	0.23
$item_7$	0	1	5	1	1	1	0.85

Similarity measure

Collaborative filtering: item to item

Item-Item Collaborative filtering

Weighted sum
(4x0.9+5x0.64+5x0.85)
(0.9+0.64+0.85)
= 4.62

			u_3	u_4	u_5	U_6	
			5	4	0	3	0.63
				1	5	1	0.45
$item_3$	0	1	4.62	2	1	4	
$item_4$	1	1	4	1	1	2	0.9
$item_5$	3	2	5	0	0	3	0.64
$item_6$	4	3	0	0	4	0	0.23
$item_7$	0	1	5	1	1	1	0.85

Similarity measure

Amazon Item-Item filtering

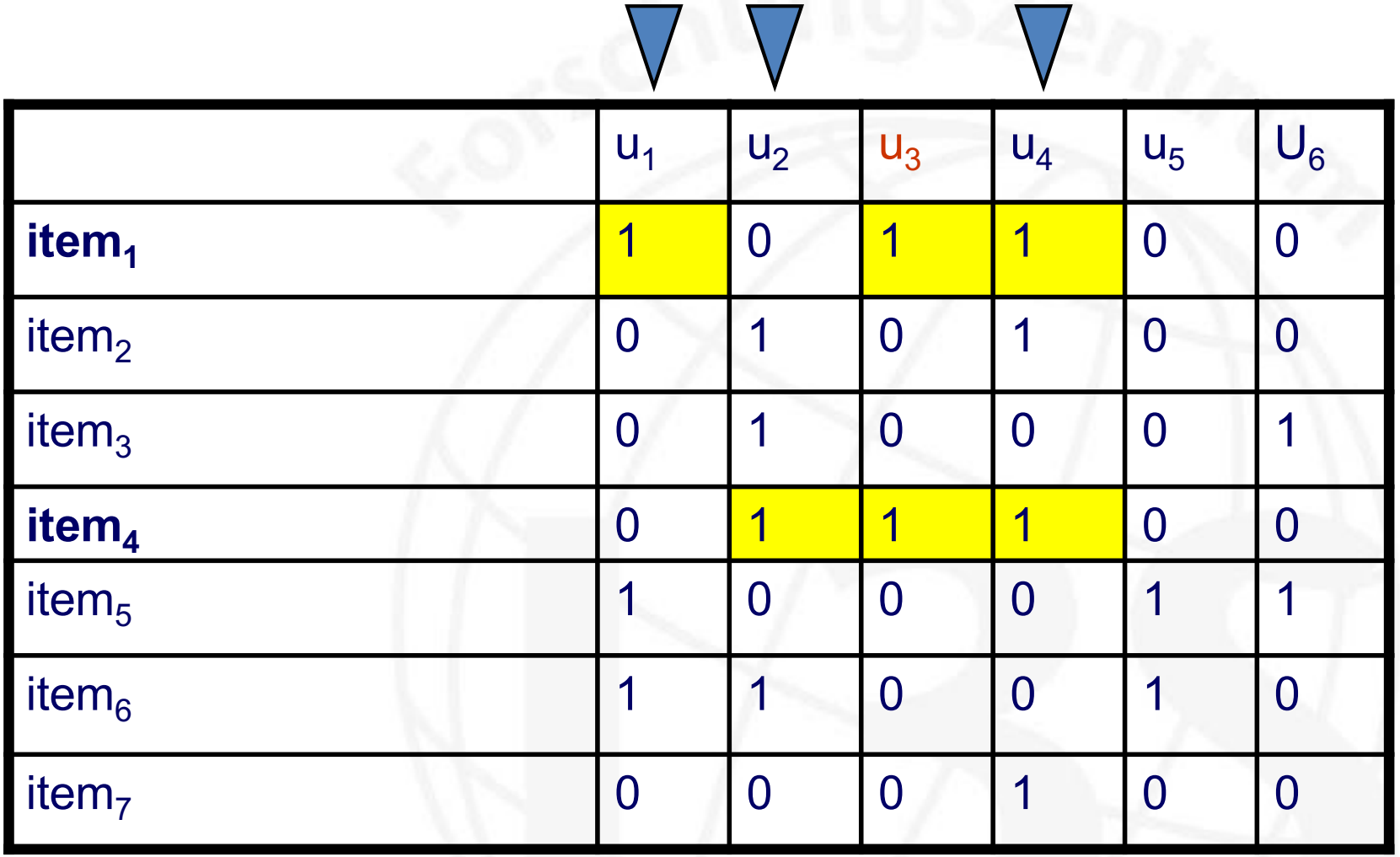
Context: Items that have been bought are marked with
Task: Recommend items to the user

	u_1	u_2	u_3	u_4	u_5	U_6
item$_1$	1	0	1	1	0	0
item$_2$	0	1	0	1	0	0
item$_3$	0	1	0	0	0	1
item$_4$	0	1	1	1	0	0
item$_5$	1	0	0	0	1	1
item$_6$	1	1	0	0	1	0
item$_7$	0	0	0	1	0	0

Linden, Simith and York (2003) from the resources for this lecture

Context: Items that have been bought are marked with 1
Task: Recommend items to the user

	u_1	u_2	u_3	u_4	u_5	U_6
item$_1$	1	0	**1**	1	0	0
item$_2$	0	1	0	1	0	0
item$_3$	0	1	0	0	0	1
item$_4$	0	1	**1**	1	0	0
item$_5$	1	0	0	0	1	1
item$_6$	1	1	0	0	1	0
item$_7$	0	0	0	1	0	0



	u_1	u_2	u_3	u_4	u_5	U_6
item$_1$	1	0	1	1	0	0
item$_2$	0	1	0	1	0	0
item$_3$	0	1	0	0	0	1
item$_4$	0	1	1	1	0	0
item$_5$	1	0	0	0	1	1
item$_6$	1	1	0	0	1	0
item$_7$	0	0	0	1	0	0

Register pairs:

$[u_3,u_1,\mathbf{i_1}]$ - (i_1, i_5), (i_1,i_6)

$[u_3,u_4,\mathbf{i_1}]$ – (i_1,i_2), (i_1,i_7)

$[u_3,u_2,\mathbf{i_4}]$ – (i_4,i_2), (i_4,i_3), (i_4,i_6)

$[u_3,u_4,\mathbf{i_4}]$ – (i_4,i_2), (i_4,i_7)

	u_1	u_2	u_3	u_4	u_5	U_6
$item_1$	1	0	1	1	0	0
$item_2$	0	1	0	1	0	0
$item_3$	0	1	0	0	0	1
$item_4$	0	1	1	1	0	0
$item_5$	1	0	0	0	1	1
$item_6$	1	1	0	0	1	0
$item_7$	0	0	0	1	0	0

	u_1	u_2	u_3	u_4	u_5	U_6
$item_1$	1	0	1	1	0	0
$item_2$	0	1	0	1	0	0
$item_3$	0	1	0	0	0	1
$item_4$	0	1	1	1	0	0
$item_5$	1	0	0	0	1	1
$item_6$	1	1	0	0	1	0
$item_7$	0	0	0	1	0	0

Calculate similarity for all pairs identified at Step 2

Calculate similarity between items

(i_1, i_5)=.33, (i_1,i_6)=.33

(i_1,i_2)=.41, (i_1,i_7)=.58

(i_4,i_2)=.82, (i_4,i_3)=.41, (i_4,i_6)=.33

(i_4,i_7)=.58

			u_3	u_4	u_5	U_6
$item_1$	1	0	1	1	0	0
$item_2$	0	1	0	1	0	0
$item_3$	0	1	0	0	0	1
$item_4$	0	1	1	1	0	0
$item_5$	1	0	0	0	1	1
$item_6$	1	1	0	0	1	0
$item_7$	0	0	0	1	0	0

Calculate similarity for all pairs identified at Step 2

	u_1	u_2	u_3	u_4	u_5	U_6
$item_1$	1	0	1	1	0	0
$item_2$	0	1	0	1	0	0
$item_3$	0	1	0	0	0	1
$item_4$	0	1	1	1	0	0
$item_5$	1	0	0	0	1	1
$item_6$	1	1	0	0	1	0
$item_7$	0	0	0	1	0	0

Calculate similarity between items

$(i_1, i_5)=.33$, $(i_1,i_6)=.33$

$(i_1,i_2)=.41$, **$(i_1,i_7)=.58$**

$(i_4,i_2)=.82$, $(i_4,i_3)=.41$, $(i_4,i_6)=.33$

$(i_4,i_7)=.58$

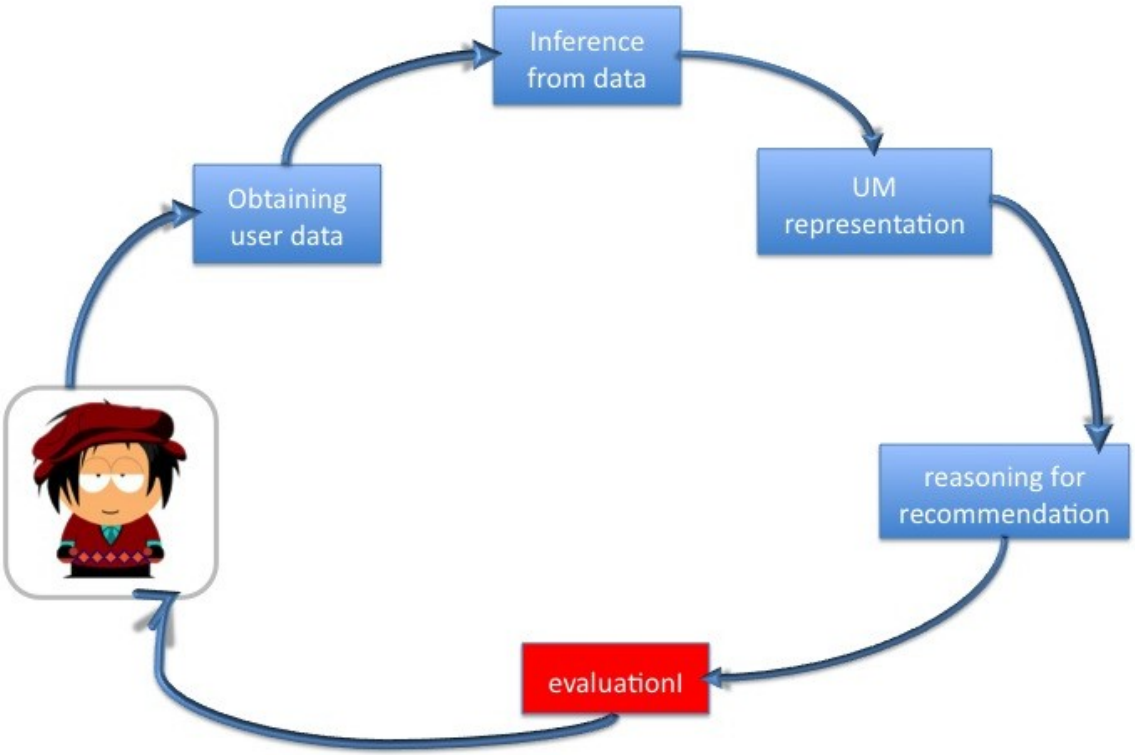
	u_1	u_2	u_3	u_4	u_5	U_6
$item_1$	1	0	1	1	0	0
$item_2$	0	1	0	1	0	0
$item_3$	0	1	0	0	0	1
$item_4$	0	1	1	1	0	0
$item_5$	1	0	0	0	1	1
$item_6$	1	1	0	0	1	0
$item_7$	0	0	0	1	0	0

Hybrid recommender systems

They combine different recommender techniques (content and collaborative) to mitigate the weakness of the individual approaches. Several ways to merge:

- mixed, recommendation generated from several RSs are presented together
- switching, one RS is turned on and the other is turned off
- features combination, the features used by different recommender are integrated and combined in a single data source

User Modeling process: evaluation



Evaluation

Need for a layered-evaluation

user-based: formative and summative evaluation with users

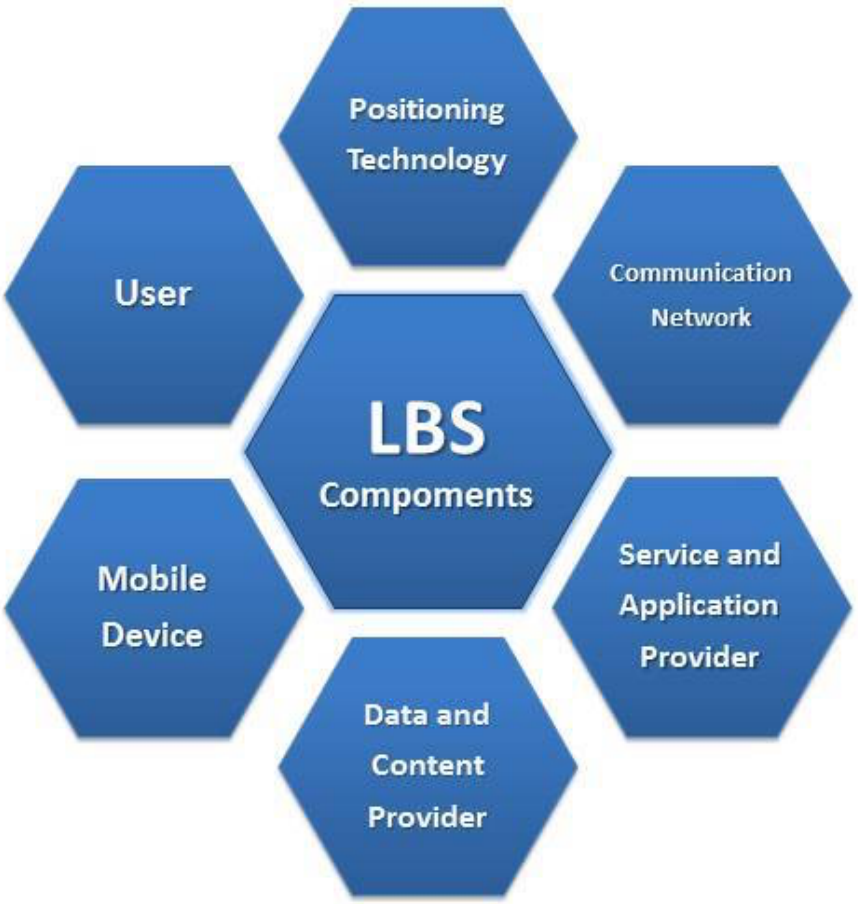
data-set based: metrics and statistics (MAE –RMSE, precision, recall)

We don’t have time to see this

Location based recommenders

Location-based services

The term *location-based services* (*LBS*) i- denotes applications integrating geographic location (i.e., spatial coordinates) with the general notion of services. Examples of such applications include emergency services, car navigation systems, tourist tour planning, or "yellow maps" (combination of yellow pages and maps) information delivery.



Phillips, Alan, et al. "Location-based services." U.S. Patent No. 7,848,765. 7 Dec. 2010.

Location-based services

Location Based Services include a very wide range of services that provide information to the user based on her physical location

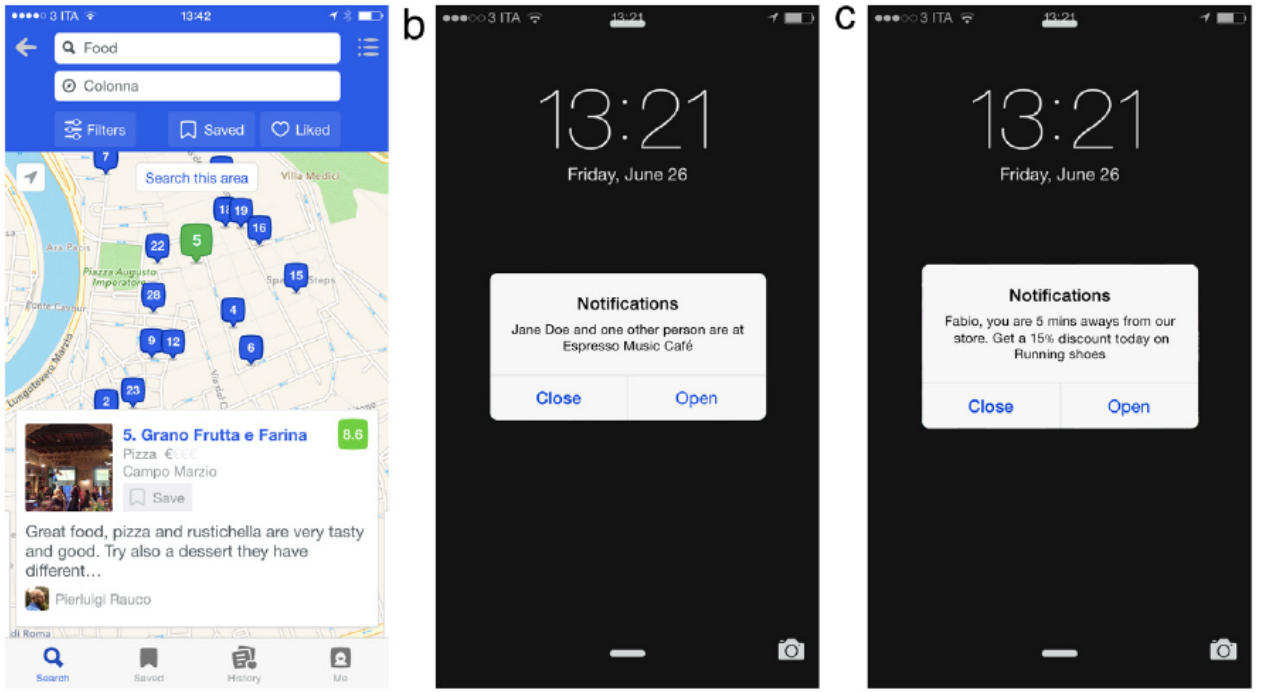
Location services can be defined as *services that integrate a mobile device's location or position with other information so as to provide added value to a user*.

Mobile services are of three types:

1. for navigation (interactive maps, route calculation ...),
2. for information (signaling places of POIs tourist-cultural interest, news, events, contacts ...)
3. for marketing (marketing of proximity, in-store actions, targeted promotions ...).

Interaction paradimgs

- **Pull**: when the user takes the initiative by querying the LBS
- **Push:** when the service is given the initiative to deliver POIs
- **Ads**: where the POIs take the form of a location-enabled mobile ads.



F. Gasparetti / Pervasive and Mobile Computing 38 (2017) 446–473

Points of Interest (POI)

A POI is a specific location (e.g., museum, restaurant) or a clealy defined area (a park, a nature reserve) that someone my find interesting or important in a given situation (Gasparetti, 2019)

POIs are characherized by different features:

- categories and sub-categories
- coordinates
- popularity
- Category-related dimensions (price, cleaness, etc)

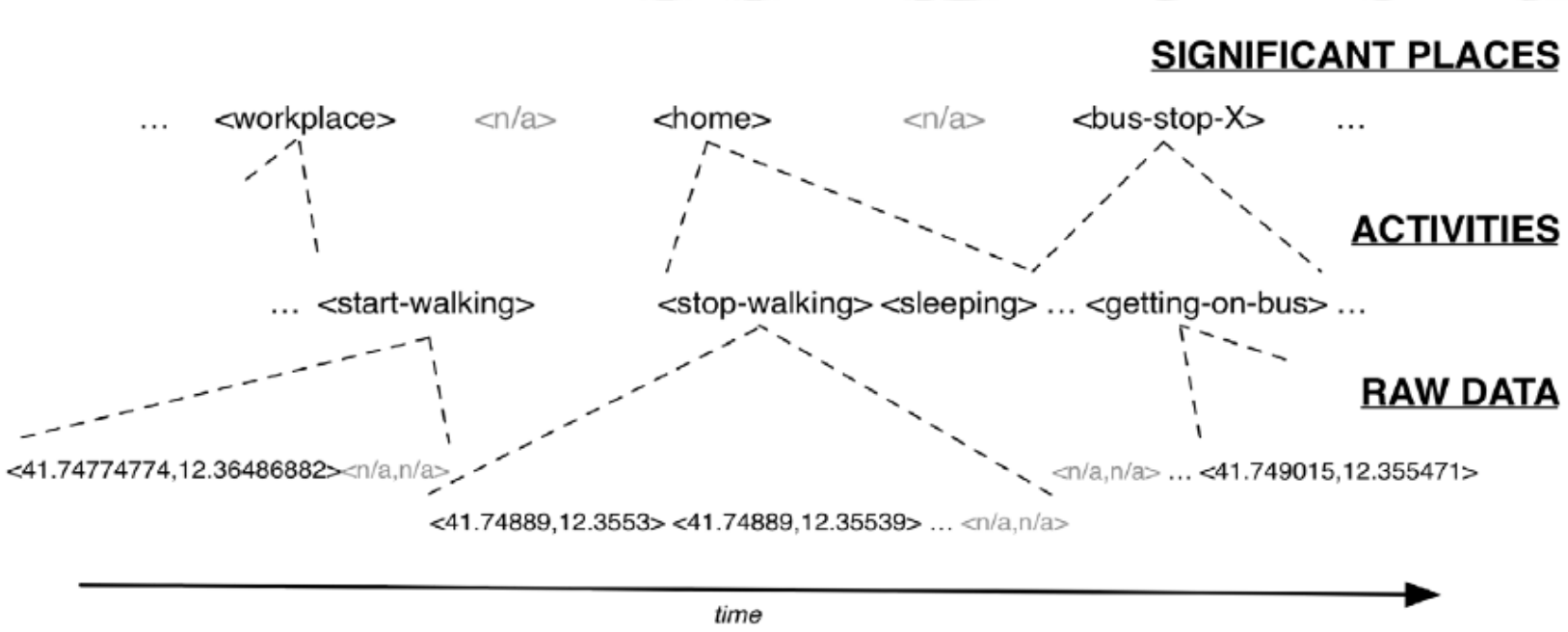
How to gather POIs features

EXPLICIT FEEDBACK

- check-in of user
- tags, comments

IMPLICIT FEEDBACK

- GPS
- Sensors in the mobile phone (→ features extractions)



Location-based services

Current, LBSs provide users with service based on current location, customers ratings, and features of the venue, **but do no take into account user features.**

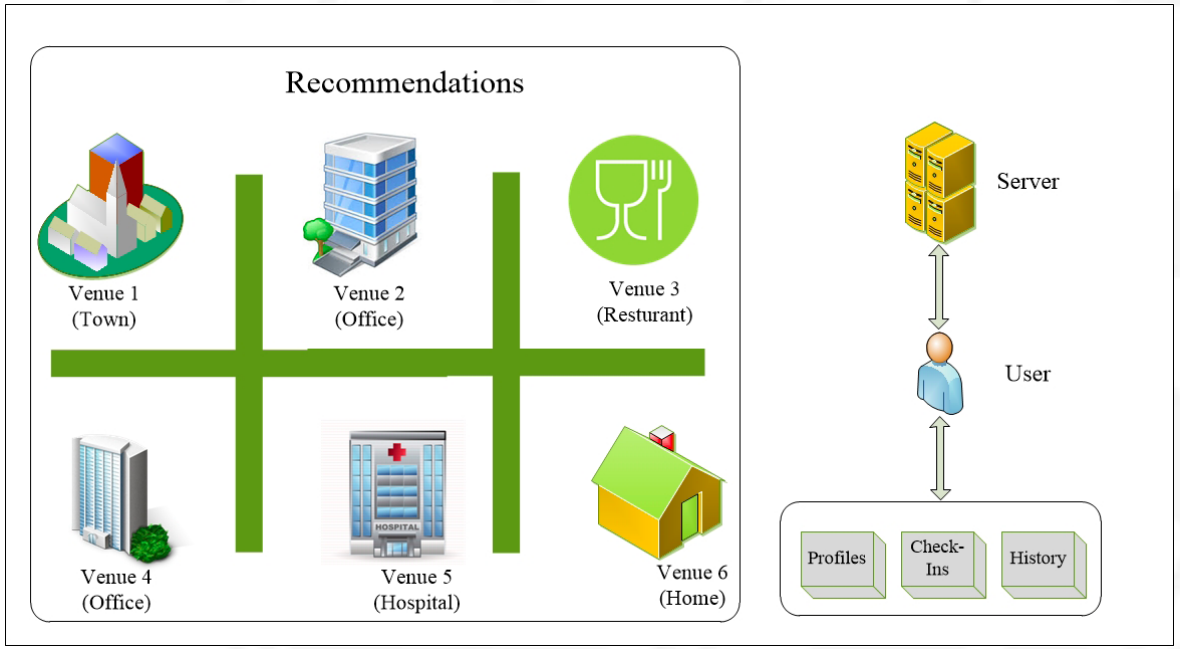
LBS can be enhanced by

- Considering other user features (user preferences and needs)
    - LB Recommenders
- Considering other information regarding the situations or contexts beside place (time, people that are present, ..)
    - CONTEXT (CAR) Recommender systems
        - POIs recommender
        - Routes recommender

Location recommendations

Based on

- experts' opinions
- popularity
- user preferences (Bao et al.2012)



CICERO	Sansonetti et al, 2019
What is recommended	POIs and Routes
How	Collaborative filtering, linked open data to represent resources
User features:	User interests
Context features	Location, time
How gathered	Social media analysis

Giuseppe Sansonetti, Fabio Gasparetti, Alessandro Micarelli, Federica Cena, Cristina Gena: **Enhancing cultural recommendations through social and linked open data.** User Model. User-Adapt. Interact. 29(1): 121-159 (2019)

SMARTMUSEUM	Ruotsalo et al. 2013
What is recommended	museums or buildings of architectural interest, and objects on those sites, such as sculptures or other works of art, and provides explanatory descriptions and multimedia content associated with individual objects).
How	SemanticWeb languages (RDF, RDFS) as the form of data representation. Ontologies are used to bridge the semantic gap between heterogeneous content descriptions, sensor inputs, and user profiles.
User features:	User interests
Context features	Location, time
How gathered	Social network (facebook), prosposed items

Ruotsalo, T., Haav, K., Stoyanov, A., Roche, S., Fani, E., Deliai, R., Mäkelä, E., Kauppinen, T., Hyvönen, E.: Smartmuseum: a mobile recommender system for the web of data.Web Semant. Sci. Serv. Agents World Wide Web **20**, 50–67 (2013).

	Kurashima et al. (2010)
What is recommended	routes
How	Exploites photographers' histories as held by Flickr.
User features:	User interests
Context features	Location, time
How gathered	Social network (fliker):geotagged pictures, , past traverls

Kurashima, T., Iwata, T., Irie, G., Fujimura, K.: Travel route recommendation using geotags in photo sharing sites. In: Proceedings of the 19th ACM International Conference on Information and Knowledge Management, pp. 579–588. ACM, New York, CIKM '10 (2010).

	Hagen et al. 2005)
What is recommended	When to visit a POI (time-based itineraries)
How	Ontologies to model user interests. The recommender proposes one or more itineraries that maximize the number of POIs given the initial time frame. Non-accessible POIs (e.g., opening hours do not fall back into the time frame) are not included in the itineraries.
User features:	User interests, tastes, contraints
Context features	time
How gathered	Social network (fliker):geotagged picturs, , past traverls

Hagen, K., Kramer, R., Hermkes, M., Schumann, B., Mueller, P.: chap Semantic Matching and Heuristic Search for a Dynamic Tour Guide. In: Proceedings of the International Conference in Innsbruck, pp. 149–159. Springer, Vienna (2005).

Challenges

- Data sparsity
- Cold start
- Over specialisation problem
- Scalability
- evaluation metrics
- Trust (The users are more likely to accept the recommendations if their confidence in the system is high (Avazpour et al. 2014).

- → (Shani & Gunawardana 2011). The user has more trust on the system if the recommendations generated by the system best match the users preferences. → CARS

Context-aware Recommendation

slides partially derive from Yong Zheng

What is context

- "**Context** is any information that can be used to characterizethe situation of an entity" by AnindK. Dey, 2001

  Objective features:
  - physical context (= LBS)
  - temporal context (= LBS)
  - social context
  - interaction media context (the device used)
- Subjective features
  - modal context (the current state of mind of the user, the users goals, mood, experience, and cognitive capabilities)

Adomavicius, Gediminas, and Alexander Tuzhilin.
"Context-aware recommender systems." *Recommender systems handbook*.
Springer, Boston, MA, 2011. 217-253.

What is context

Baldauf et al. 2007 introduce three principal categories of context factors:

- **spatio-temporal/environmental:** basic attributes such as time, location, direction and the current external circumstances surrounding the user such as the weather condition
- **task-related:** what the user is currently doing, e.g., driving or listening to music.
- **Personal**: related to the personal state or condition such as her emotional and physical states.

M. Baldauf, S. Dustdar, F. Rosenberg, A survey on context-aware systems, Int. J. Ad Hoc Ubiquitous Comput. 2 (4) (2007) 263–277.

What is context

Contexts are those variables which may change when a same activity is performed again and again.

- **Examples:**

  Watching a movie: time, location, companion, etc

  Listening to a music: time, location, emotions, occasions, etc

  Party or Restaurant: time, location, occasion, etc

  Travels: time, location, weather, transportation condition, etc

Context-aware RecSys (CARS)

- Traditional RS: Users × Items ⟶ Ratings
- Contextual RS: Users × Items × Contexts ⟶ Ratings

User	Item	Rating	Time	Location	Companion
U1	T1	3	Weekend	Home	Kids
U1	T2	5	Weekday	Home	Partner
U2	T2	2	Weekend	Cinema	Partner
U2	T3	3	Weekday	Cinema	Family
U1	T3	?	Weekend	Cinema	Kids

Terminology in CARS

- Example of Multi-dimensional Context-aware Data set

User	Item	Rating	Time	Location	Companion
U1	T1	3	Weekend	Home	Kids
U1	T2	5	Weekday	Home	Partner
U2	T2	2	Weekend	Cinema	Partner
U2	T3	3	Weekday	Cinema	Family
U1	T3	?	Weekend	Cinema	Kids

- Context Dimension: time, location, companion
- Context Condition: Weekend/Weekday, Home/Cinema
- Context Situation: {Weekend, Home, Kids}

Context Acquisition

How to Collect the context and user preferences in contexts?

- **By User Surveys or Explicitly Asking for User Inputs**

  Predefine context & ask users to rate items in these situations;

  Or directly ask users about their contexts in user interface;

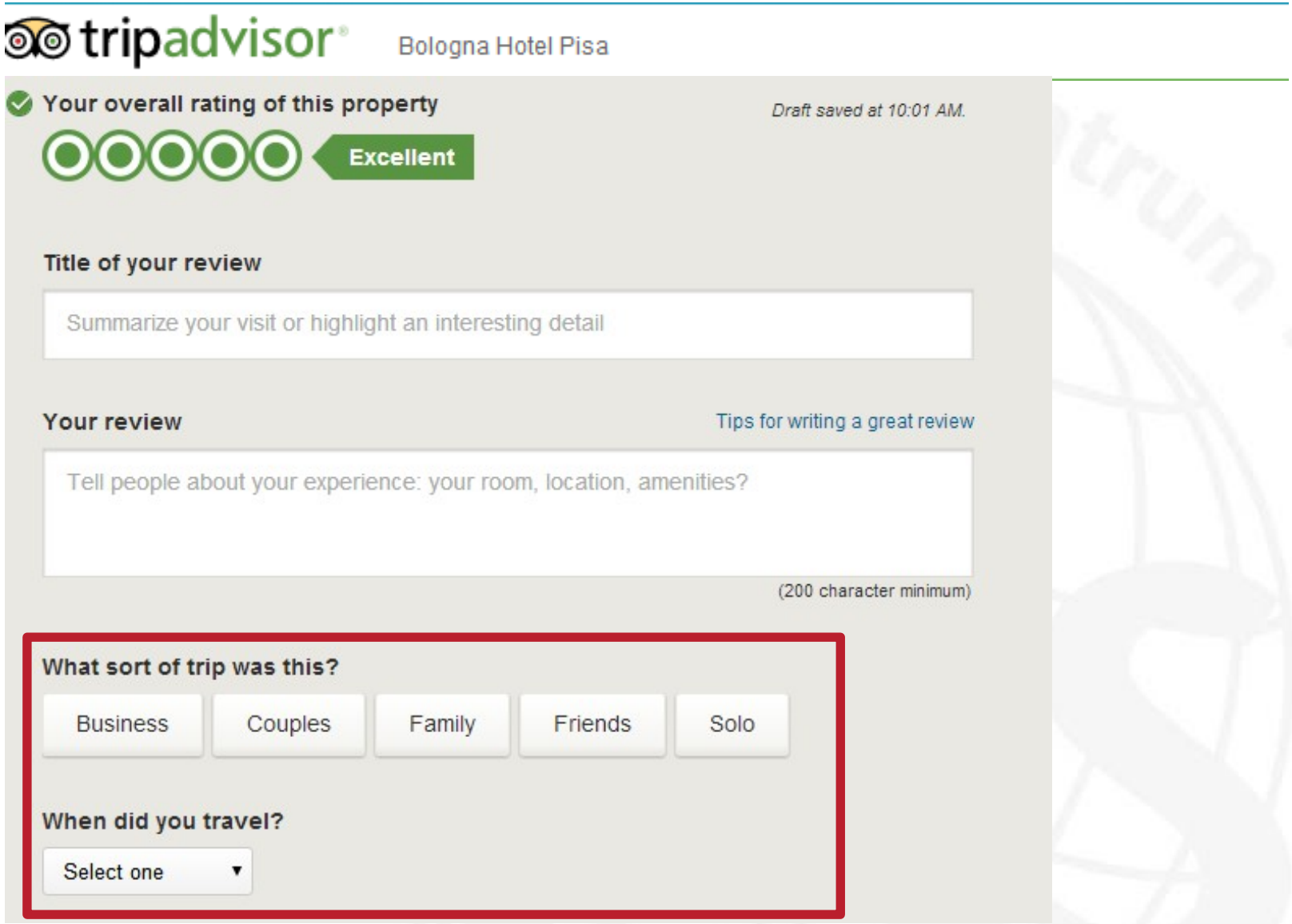
- **By Usage data**

  The log data usually contains time and location (at least);

  User behaviors can also infer context signals;

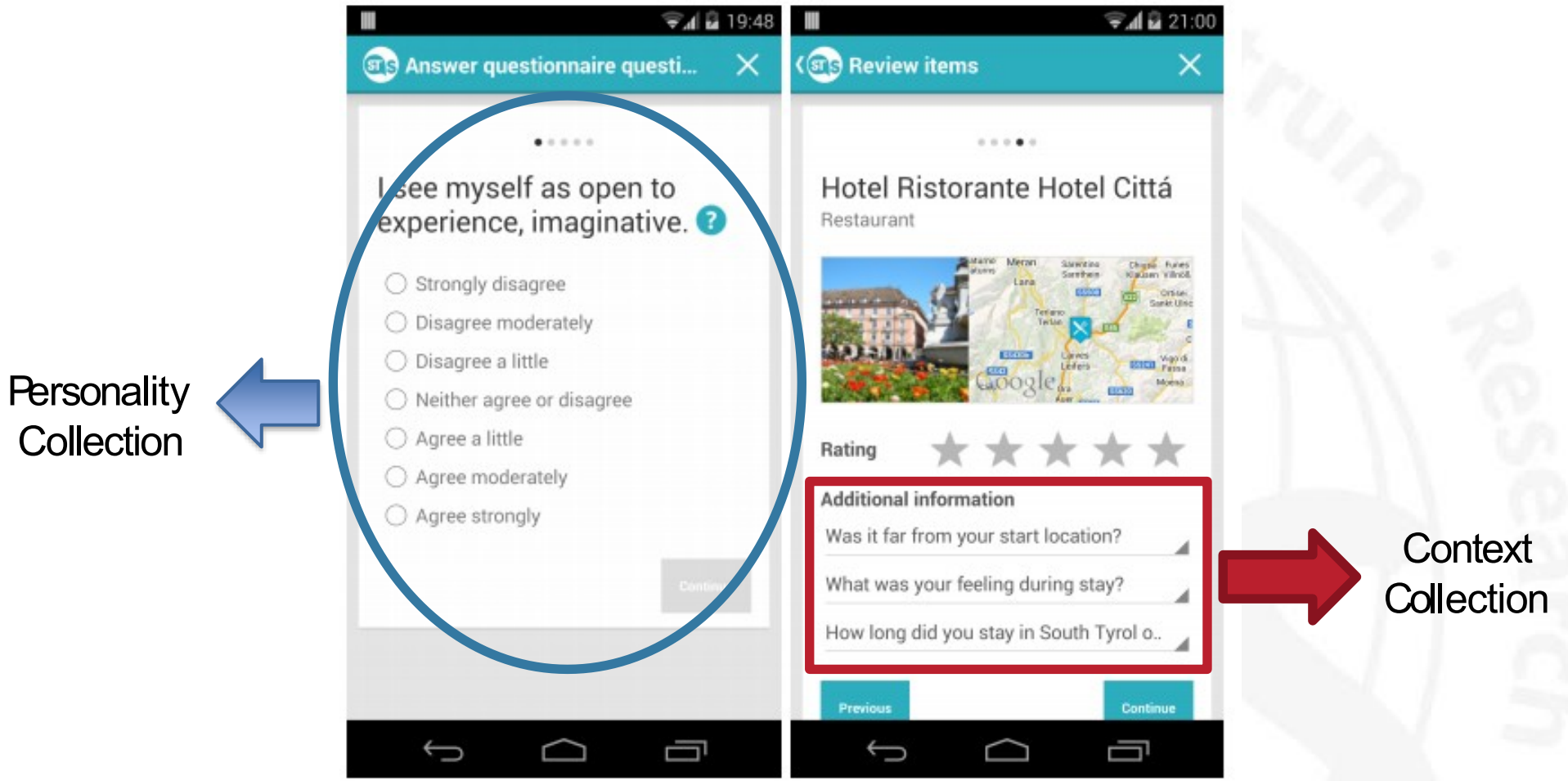
Examples: Context Acquisition (Explicit)

Examples: Context Acquisition (Explicit)

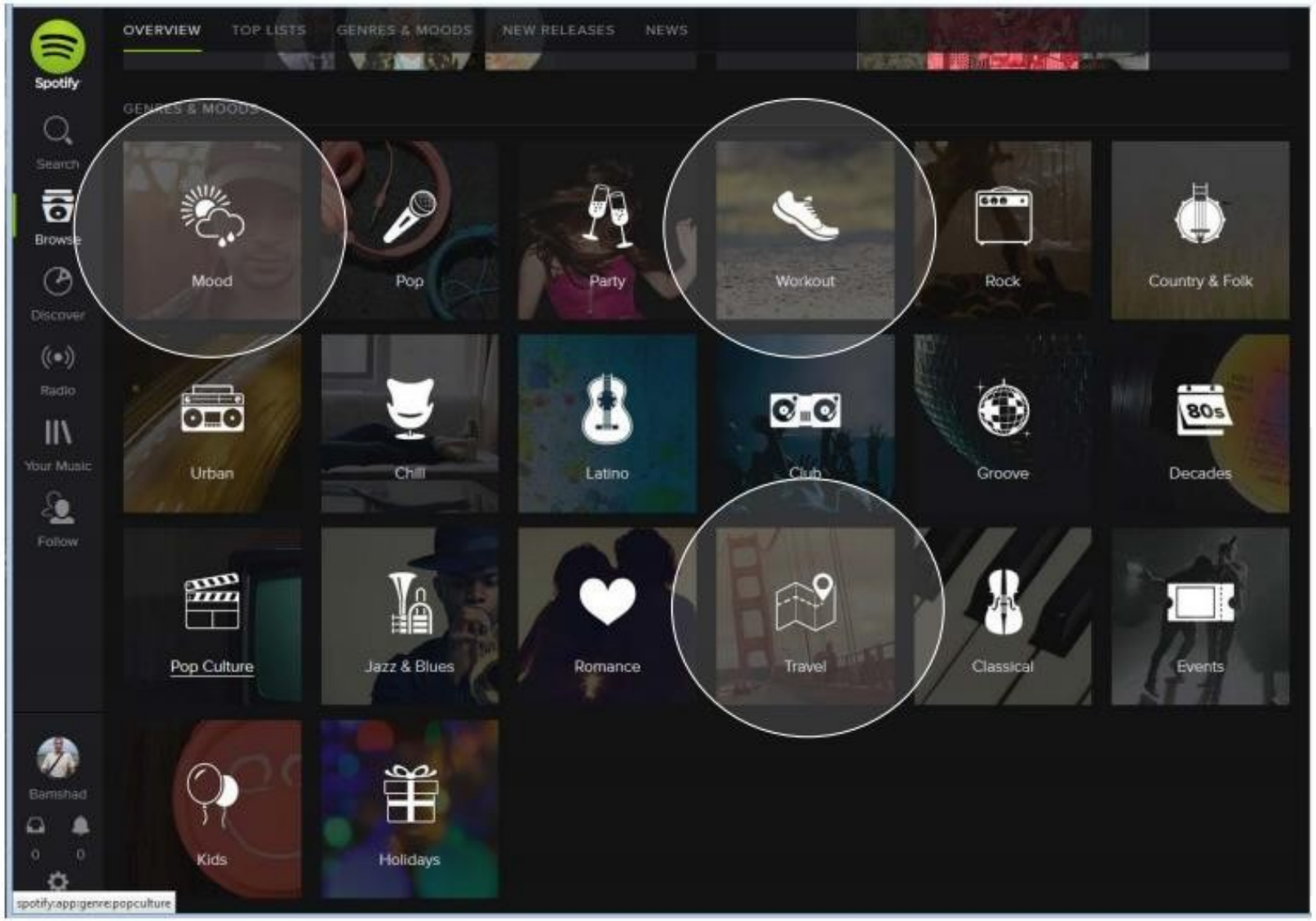


Examples: Context Acquisition (Explicit)

Mobile App: South Tyrol Suggests

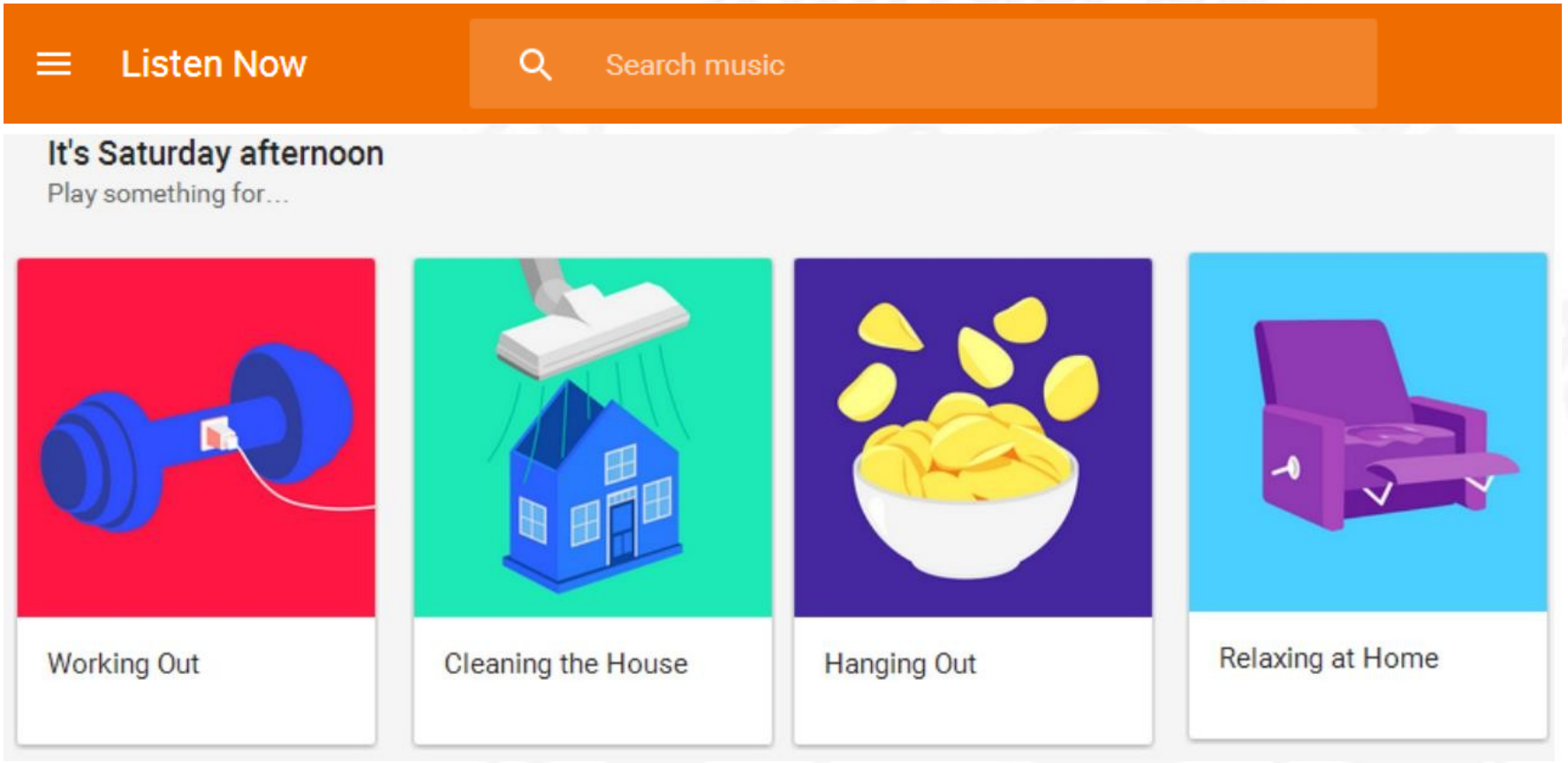


Examples: Context Acquisition (PreDefined)

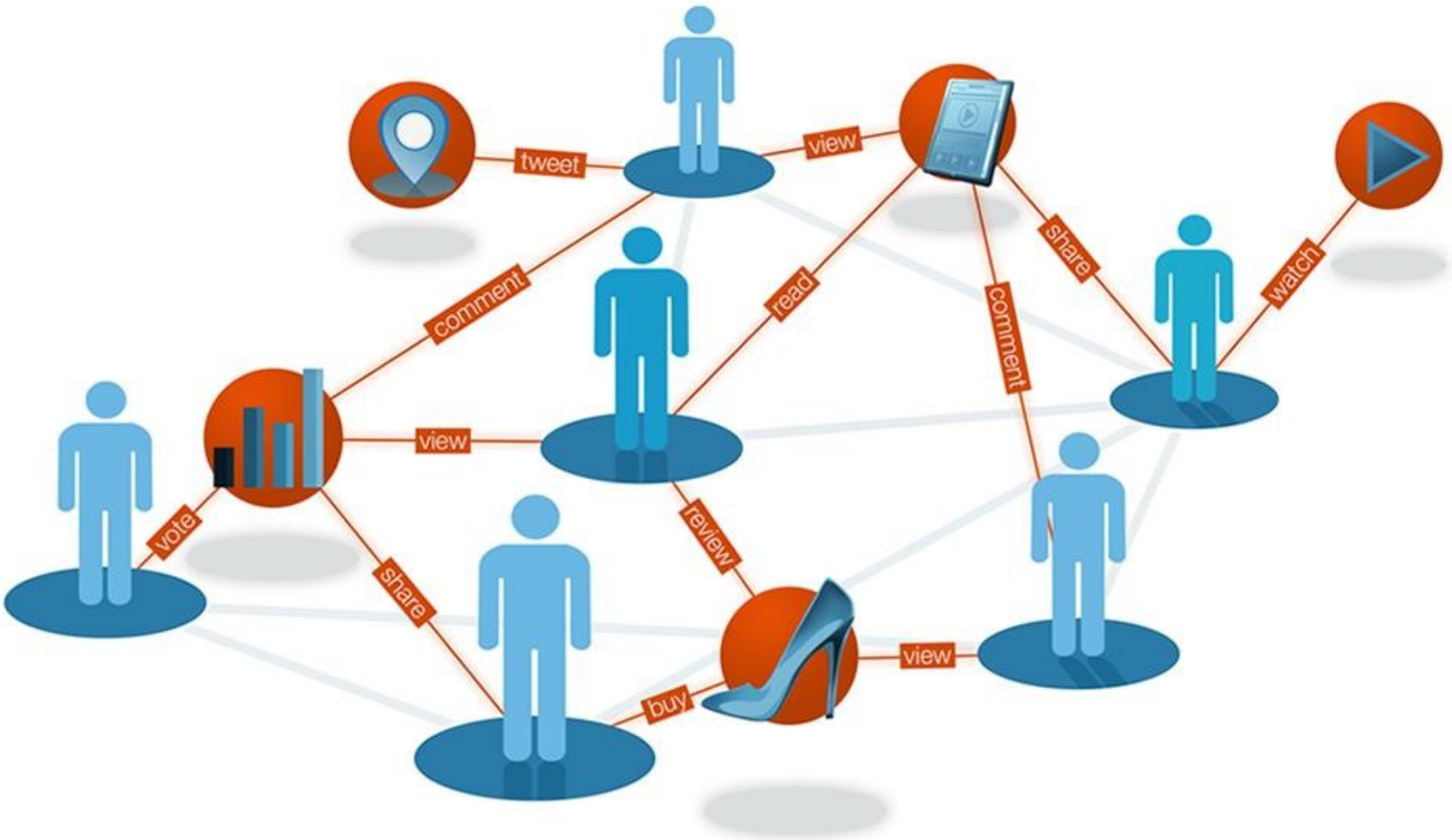


Examples: Context Acquisition (PreDefined)

Google Music: Listen Now



Examples: Context Acquisition (User Behavior)



Context Relevance

Apparently, not all of the context are relevant or influential

- By User Surveys

  e.g., which ones are important for you in this domain
- By Feature Selection

  e.g., Principal Component Analysis (PCA) e.g., Linear Discriminant Analysis (LDA)
- By Statistical Analysis or Detection on Contextual Ratings Statistical test, e.g., Freeman-Halton Test, entropy, mutual information, etc

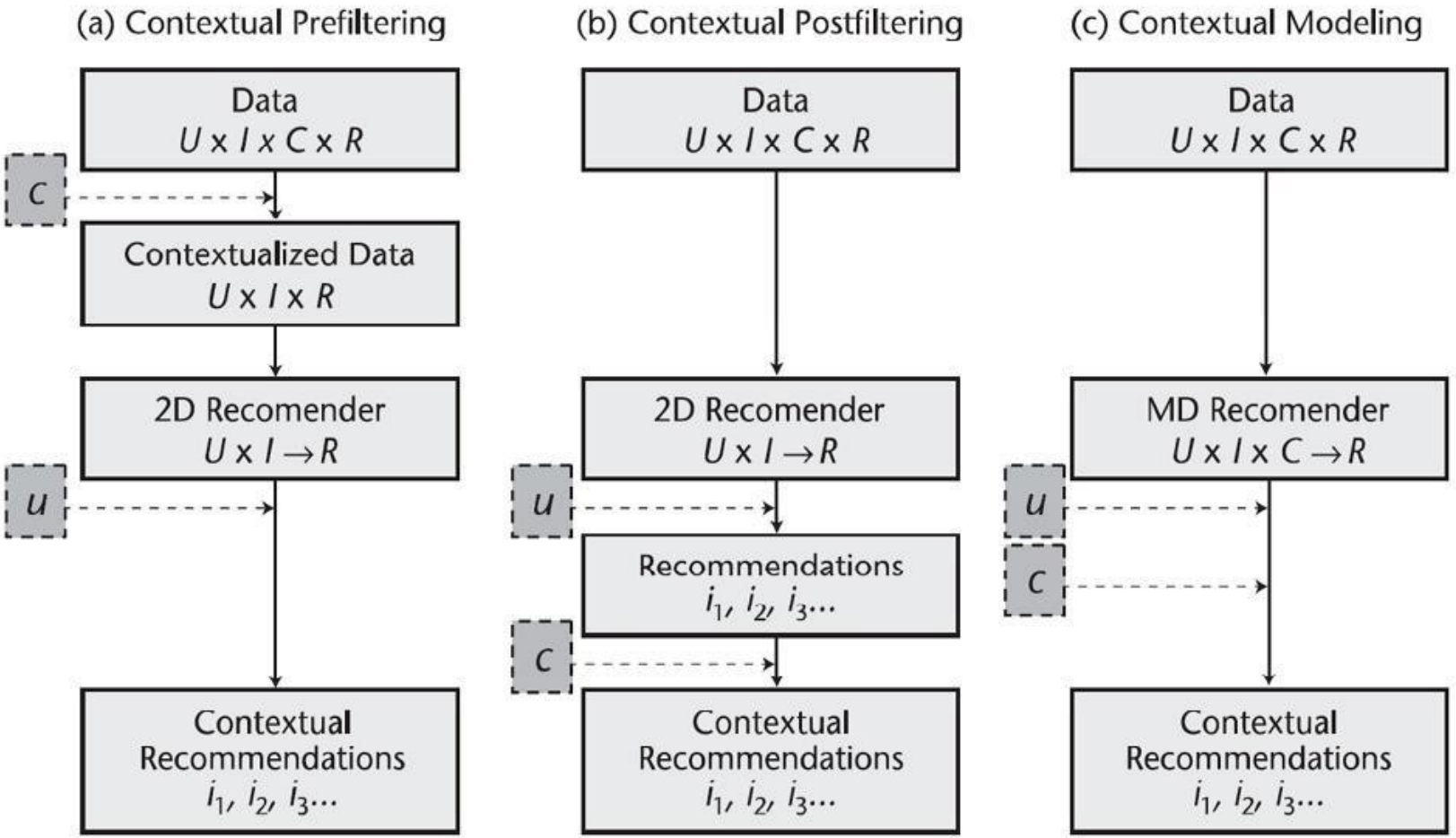
Odic, Ante, et al. "Relevant context in a movie recommender system: Users' opinion vs. statistical detection." CARS Workshop@ACM RecSys 2012

Outline

- Context-aware Recommendation
  - Intro: Does context matter?
    - Definition: What is Context?
    - Acquisition: How to collect context?
    - Selection: How to identify the relevant context?
  - Context Incorporation: Algorithms
    - Context Filtering
    - Context Modeling
  - Other Challenges and CARSKit

Context-aware RecSys (CARS)

- There are three ways to build algorithms for CARS



There are 3 ways to incorporate context in a RS

1. Context filtering (pre): before computing the rating estimation the context features are used to filtered items to be considered
2. Context filtering (post): the rating estimation doesn't change and then the list of solutions is filtered based on context features
3. Context modeling: context feature can became part of rating estimation, for example by means of tensor factorization ([43, 6], latent-factor models [45, 7, 75, 74], distributional semantic [56]

1. Example

User	Movie	Rating
U1	*Titanic*	4
U2	*Titanic*	5
U3	*Titanic*	4
U1	*Titanic*	?

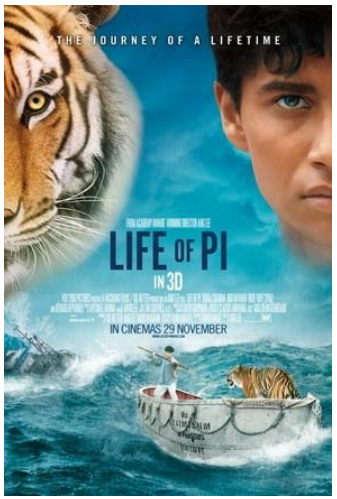
context

User	Movie	Time	Location	Companion	Rating
U1	*Titanic*	Weekend	Home	Girlfriend	4
U2	*Titanic*	Weekday	Home	Girlfriend	5
U3	*Titanic*	Weekday	Cinema	Sister	4
U1	*Titanic*	Weekday	Home	Sister	?

Context Matching ➔ Only profiles given in <Weekday, Home, Sister>
Context Relaxation ➔ Use a subset of context dimensions to match
Context Weighting ➔ Use all profiles, but weighted by context similarity

2. Item Splitting

The underlying idea in item splitting is that the nature of an item, from the user's point of view, may change in different contextual conditions, hence it may be useful to consider it as two different items. (L. Baltrunas, F.Ricci, RecSys'09) –



At Cinema

At Home

At Swimming Pool

Item Splitting

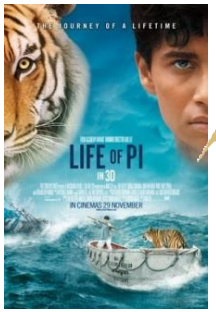
User	Item	Location	Rating
U1	M1	Pool	5
U2	M1	Pool	5
U3	M1	Pool	5
U1	M1	Home	2
U4	M1	Home	3
U2	M1	Cinema	2

High Rating

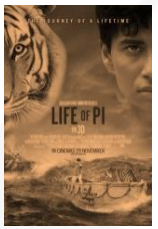
Low Rating

Significant difference?
Let's split it !!!

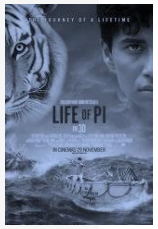
Same movie, different IDs.



M1



M11: being seen at Pool



M12: being seen at Home

Item Splitting

User	Item	Loc	Rating
U1	M1	Pool	5
U2	M1	Pool	5
U3	M1	Pool	5
U1	M1	Home	2
U4	M1	Home	3
U2	M1	Cinema	2

Transformation

User	Item	Rating
U1	M11	5
U2	M11	5
U3	M11	5
U1	M12	2
U4	M12	3
U2	M12	2

Splitting and Transformation

User	Item	Rating	Time	Location	Companion
U1	T1	3	Weekend	Home	Friend
U1	T1	5	Weekend	Cinema	Girlfriend
U1	T1	?	Weekday	Home	Family

(a) by Item Splitting

User	Item	Rating
U1	T11	3
U1	T12	5
U1	T11	?

(b) by User Splitting

User	Item	Rating
U12	T1	3
U12	T1	5
U11	T1	?

(c) by UI Splitting

User	Item	Rating
U12	T11	3
U12	T12	5
U11	T11	?

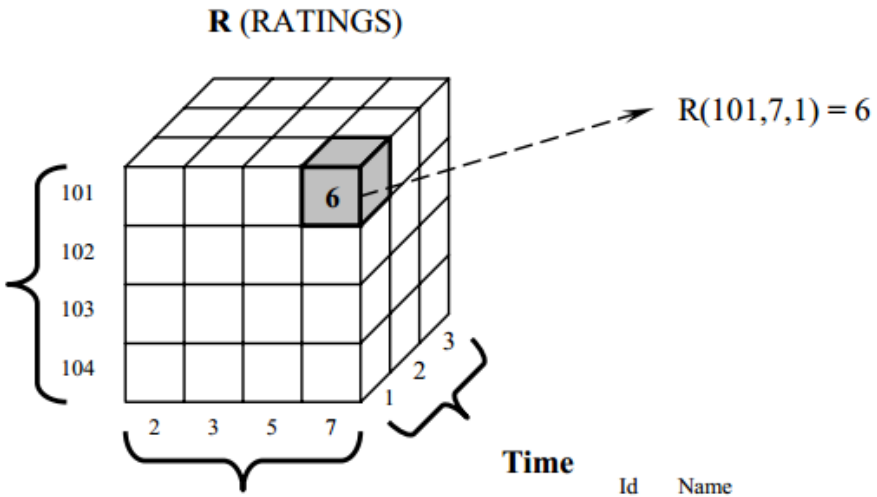
Independent Contextual Modeling

- **Tensor Factorization**

  Multi-dimensional space: *Users* × *Items* × *Contexts* → *Ratings*

User

Id	Name	Age
101	John	25
102	Bob	18
103	Alice	27
104	Mary	21



Item

Id	Name	Cost
2	AB17	250.00
3	AB23	299.95
5	XY70	150.00
7	ZZ55	115.50

Time

Id	Name
1	Weekday
2	Weekend
3	Holiday

Each context variable is modeled as an individual and independent dimension in addition to user & item dims.

Thus we can create a multidimensional space, where rating is the value in the space.

Dependent Contextual Modeling

- Dependence between Users/Items and Contexts
  - User and Context, such as user splitting
  - Item and Context, such as item splitting

For example, if a user can be splitted by time is weekend or not. It tells this user is dependent with this context.

- Dependence between Every two Contexts
  - Deviation-Based: rating deviation between two contexts
  - Similarity-Based: similarity of rating behaviors in two contexts

New Applications

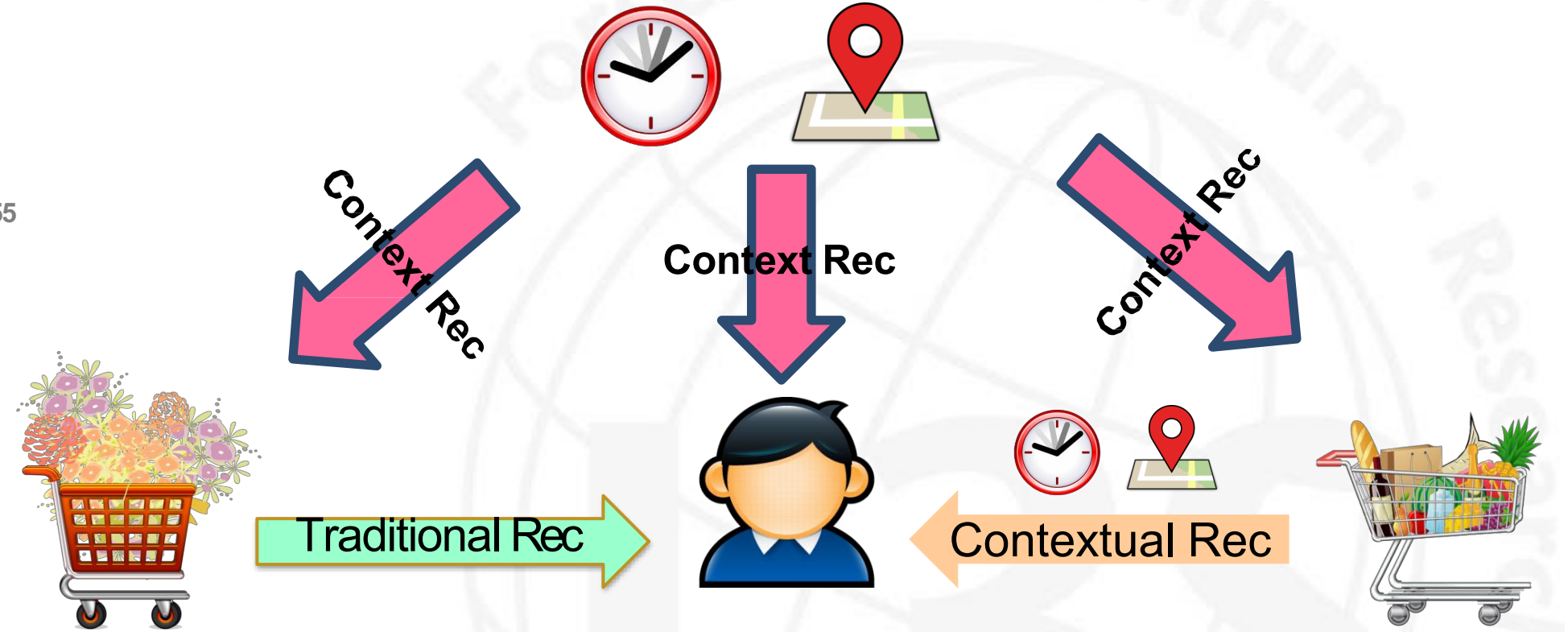
- More applications are in demand:

  - Not only e-commerce, movies, music, etc
  - Tourism: Trip planner, Traffic analyzer and planner
  - MOOC: online learning via different characteristics
  - Life Long: Digital health, daily activity tracker
  - Shared Economy: Uber, Airbnb

Context Suggestion

Context Suggestion

- Task: Suggest a list of contexts to users (on items)



Context Suggestion: Motivations

- Maximize user experience It is not enough to recommend items only

Partners at Cinema

Family at Home

Partners at Swimming Pool

Context Suggestion: Motivations

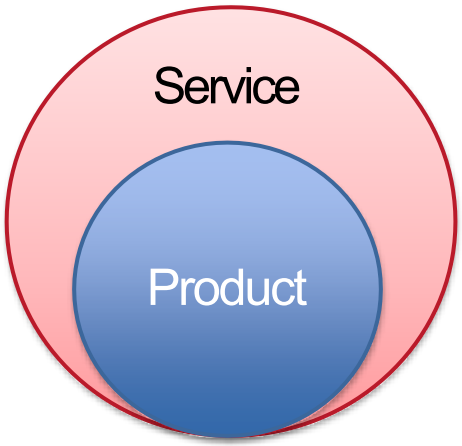
- To maximize user experience (UX)

Example: Evolution in Retails

Context Suggestion: Motivations

- To maximize user experience (UX)

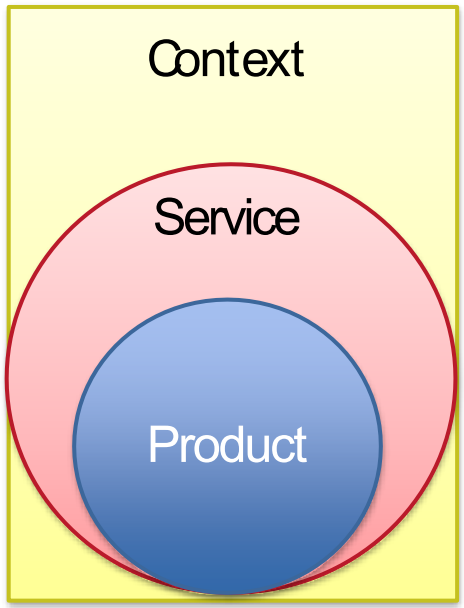
Example: Evolution in Retails



Context Suggestion: Motivations

- To maximize user experience (UX)

Example: Evolution in Retails



Context Suggestion: Applications

Customers Who Bought This Item Also Bought

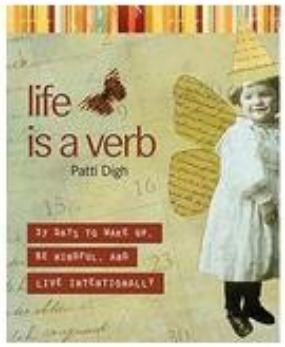
As a gift for Mother's Day

Input is user; Output is day + books

160

Magical Journey: An Apprenticeship in Contentment
› Katrina Kenison
135
Paperback
$12.05 Prime

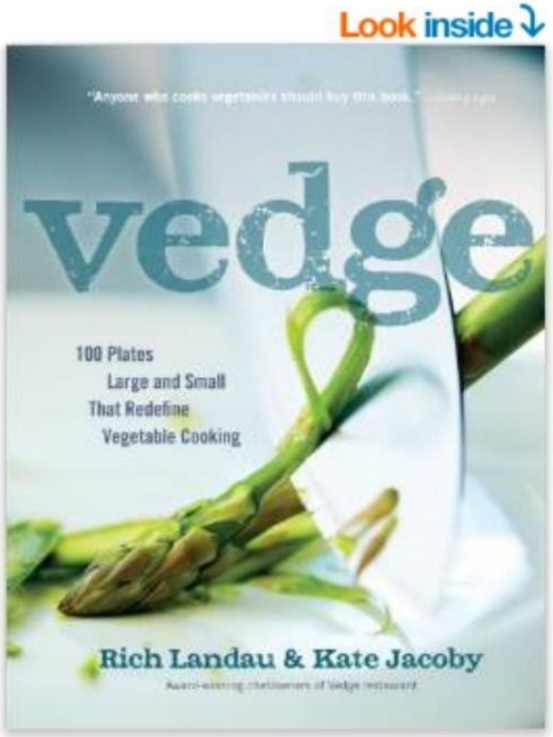
Mitten Strings for God: Reflections for Mothers in a Hurry
› Katrina Kenison
64
Paperback
$11.95 Prime



Life Is a Verb: 37 Days To Wake Up, Be Mindful, And Live Intentionally
› Patti Digh
146
Paperback
$13.96 Prime

Lift
› Kelly Corrigan
98
Hardcover
$13.37 Prime

Context Suggestion: Applications



See all 2 images

Vedge: 100 Plates Large and Small That Redefine Vegetable Cooking Hardcover – September 3, 2013

by Rich Landau (Author), Kate Jacoby (Author), Joe Yonan (Foreword)

★★★★½ 54 customer reviews *This is a good gift for your Mom!*

See all 4 formats and editions

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$9.48	$18.27 Prime	from $32.67
Read with our free app	28 Used from $12.07 48 New from $15.00	2 Used from $32.67 5 New from $34.00

Customers Who Bought This Item Also Bought As a gift for Mother's Day

Magical Journey: An Apprenticeship in Contentment
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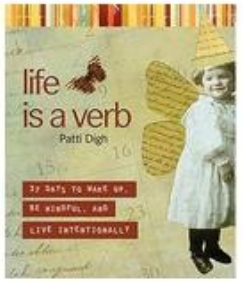

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Lift
› Kelly Corrigan
★★★★☆ 98
Hardcover
$13.37 Prime

Context-aware Data Sets

Public Data Set for Research Purpose

- Food: AIST Japan Food, Mexico Tijuana Restaurant Data
- Movies: AdomMovie, DePaulMovie, LDOS-CoMoDa Data
- Music: InCarMusic
- Travel: TripAdvisor, South Tyrol Suggests (STS)
- Mobile: Frappe

Frappe is a large data set, others are either small or sparse

Downloads and References:

https://github.com/irecsys/CARSKit/tree/master/context-aware_data_sets

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Personalized Spatial Support for People with Special Needs

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UNIVERSITA
DEGLI STUDI
DI TORINO

September, 12 2019

Index

- Inclusive cities (Disabilities)
- Technologies for inclusive cities
  - IOT
  - Crowdsourced paradigm
  - Personalisation
- Spatial support for disabilities
  - Disability-based
  - Profile-based
- Spatial supports for Austistic Spectrum Disorder (Afternoon)
  - PIUMA project

Inclusive city: why, who, how

Why inclusive cities?

- An inclusive city is a city in which the **processes of development include a wide variety of citizens** and activities.
- These cities maintain their wealth and creative power by **avoiding marginalization**, which compromises the richness of interaction upon which cities depend.

Who is Included?

Inclusive cities bring marginalized activities into the center :

- rich and poor
- different ethnicities
- students, workers and retirees
- people and products from the surrounding countryside
- children and adults
- new immigrants, visitors, and founding families
- people of all varieties of ability and **disability**

Disabilities

- Based on the definition by ONU, disability is **not a characteristic of the individual**, but is defined in relation to the surrounding environment and the result of an **interaction with a social organization that restricts activitie**s and participation due to the barriers (Bucci 2015, p. 1).

- Inclusion of people with disability is extremely important since 1 person over 10 in the world show some form of disabilities. ONU estimates indicate the presence of around 650 million disabled people across the globe.

ICIDH (1980)

LINK
International Classification of Impairments, Disabilities and Handicaps

IMPAIRMENT (Deficit) → DISABILITY → HANDICAP

IMPAIRMENT (Deficit)	DISABILITY	HANDICAP
any loss or abnormality of psychological, physiological or anatomical structure or function	any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being.	a disadvantage for a given individual that limits or prevents the fulfillment of a role that is normal
BODY	**ACTIVITY**	**SOCIETY**

Classification of disabilities

COGNITIVE DISABILITIES

Developmental Disabilities	Attention Deficit Disorder
	Autism
	Down syndrome
	Dyslexia
Mental Disabilities	Alzheimer's Disease
	Anxiety Disorder
	Depression
	Dyscalculia
	Intellectual disability
	Phobia
Physical Disabilities	Sensory disability (hear, sight dis)
	Mobility Impairment

Type of disabilities considered in the **urban space design**

	Always (%)	Sometimes (%)	Rarely (%)	Never (%)
Vision impaired	44 (21)	86 (42)	44 (21)	14 (7)
Hard of hearing	25 (12)	71 (34)	58 (28)	29 (14)
Physical / mobility impaired	166 (80)	26 (13)	3 (1)	0 (0)
Learning difficulties	17 (8)	44 (21)	67 (32)	58 (28)

COGNITIVE DISABILITIES ARE LITTLE CONSIDERED!!

Hall, 2001

How can technologyhelp in the inclusion?

- It's well known that social exclusion are multi-dimensional problems, and there is no magic bullet.
- Technoogies are now pervasive in the urban environment and can be use to foster the inclusion of people with special needs.
- Technology can help to gain **ACCESSIBILITY** of the resources.

Accessibility

- The design of products, services, devices and environments so as to be usable by people with disabilities or special needs
- To give the "ability to access"
- (different from USABILITY: a product can be used by a specific user to gain a goal with effectiveness, efficiency and satisfaction).

Accessibility

Accessibility is strong related to **UNIVERSAL DESIGN**

- " the process of creating products (object, a service, or an environment) that are usable by people with of all abilities and disabilities. Making things accessible for ALL PEOPLE (whether they have disabilities or not).

Tecnologies for inclusiveness through accessibility

- Internet of Things
- Crowdsourding and crowdsending paradigm
- Personalisation and adaptation

Internet of Things for universal access

Cena, Rapp, Torre, Internet of Things: An Opportunity for Advancing Universal Access, 2019, Y. Yesilada and S. Harper (eds.), Web Accessibility, Human–Computer Interaction Series

What is IoT?

- A worldwide **network of interconnected heterogeneous objects** (RFID, sensors, actuators, wireless devices, smart objects, embedded computers, etc.) uniquely addressable, based on standard communication protocols.
- All things are seamlessly integrated into the information network (Bandyopadhyay and Sen 2011).

IoT for accessibility

- In principle IoT can offer people with disabilities the **assistance** and **support** they need to achieve a good quality of life and allow them to participate in the social and economic life
- Conversely, if IoT devices and applications are designed **without taking into account the needs** of people with special needs they could become more of a **disabler** than an enabler (Abou-Zahra, 2017)

IoT for accessibility

The IoT paradigm can be **advance universal access**, with the aim for all people to have equal opportunity to access to information, health, education, mobility, energy, etc:

- enabling everybody, including people with physical disabilities, to have easy access to all computing resources and information services,
- providing people with disabilities with advanced assisted living (smart building, smart mobility, smart health)

(Nicolau and Montague, 2019, Carbonell, 2009)

Smart Building

- ***Remote controlling:*** IoT can help users perform tasks such as controlling appliances, switching lights and being aware of the state of home components that cannot perform otherwise.
- ***Head-Tracking Devices:*** devices involving facial movements, eyes movements, brain control, gesture recognition, to help people affected by paralysis
- ***Voice-controlled interfaces***: for helping people with visual impairments to control household equipment.
- ***Touch-screen devices*:** enable access to graphics information and reading of text content by people with hearing disabilities.

Smart Mobility

IoT may make transportation systems and city environments more accessible by opening a variety of opportunities:

- **Self-driving vehicles**: by making disable population more autonomous and independent. Driverless car technology can reduce the need for special adaptations for disabled users, such as hand controls to operate the accelerator (Kennedys, 2017).
- **Location-based services**: IoT technology may further enable visually / cognitive / age challenged persons to acquire the necessary guidance to travel across city environments by e.g., capturing geo-tagged information through their mobile phone, and return information about a pharmacy, or points of interest (Tektonidis, 2012).

Smart Health

- **Remote health monitoring**, which allows individuals to constantly track physiological parameters and share data directly with their physicians.
- For example, SPHERE employs wearable, environmental, and camera-based sensors for tracking health allowing old and patients with a chronic disease to remain in their own homes while their health continues to be monitored, as well as caretakers and doctors to promptly intervene if something happens (Zhu et al., 2015).

Crowdsourced and crowdsensed paradigm

Crowd-based paradigm

- The lack of information about the urban environment represents itself a barrier. Thus, data about places, routes, urban facilities would be of great benefit [1].
- People can provide information about urban environment (internet of persons).

Crowd-based paradigm

- **Crowdsensing** paradigm → i.e., people while moving (passively) collect data from different places using sensors from they smart phones or smart devices
- **Crowdsourcing** paradigm → people actively provide information and data about places (adding points in map, or reviews, etc)
- These paradigms can:
  - help to gather information
  - increase the sense of inclusion and partecipation of people with special needs

Crowdsourcing

- the last years, several crowdsourcing services have been developed to allow citizens to collaborate collecting data about urban accessibility, focusing mainly on physical disabilities
- https://wheelmap.org

See later other examples

Crowdsensing

- Some academic projects allowed to collected data about urban accessibility, again focusing mainly on physical disabilities, exploiting for examples accelerometer sensors on smartphones and ad hoc sensors in wheelchair
- mPASS project (Prandi, et al . 2014. mPASS: integrating people sensing and crowdsourcing to map urban accessibility. *IEEE 11th Consumer Communications and Networking Conference* (CCNC '14).

See later other examples

Personalisation techniques

Personalisation

- Personalization involves tailoring aspects of the user experience to meet the preferences or needs of the user.
- Adaptive systems based on user model are examples of personalized systems (see the MORNING TUTORIAL)
- To design services for people with special needs **a new generation** of USER MODEL is needed: **HOLISTIC USER MODEL**

Holistic User Modeling (HUM)

Holistic representation of the user that brings together:

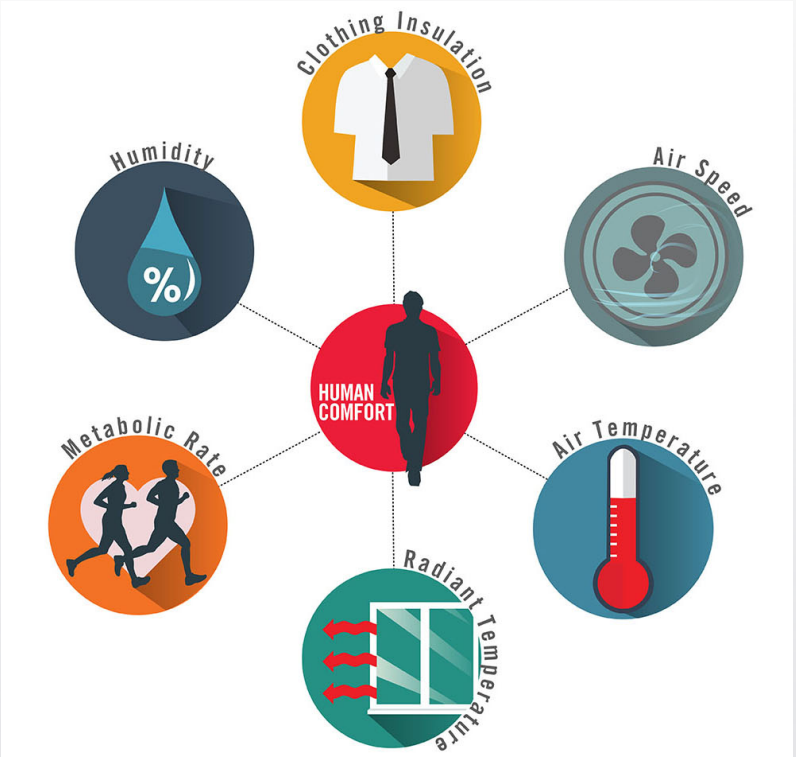
- data on user behavior in real life from sensors (wearable devices or in the environment)
- data on user behavior on the web (pattern usage, comments, posts,..)

to inferring **complex user features**

(such as habits, cognitive abilities, emotional states)

This HUM can contain information related to many aspects of the user:

- medical records
- food behavior
- physiological parameters
- psychological states, …

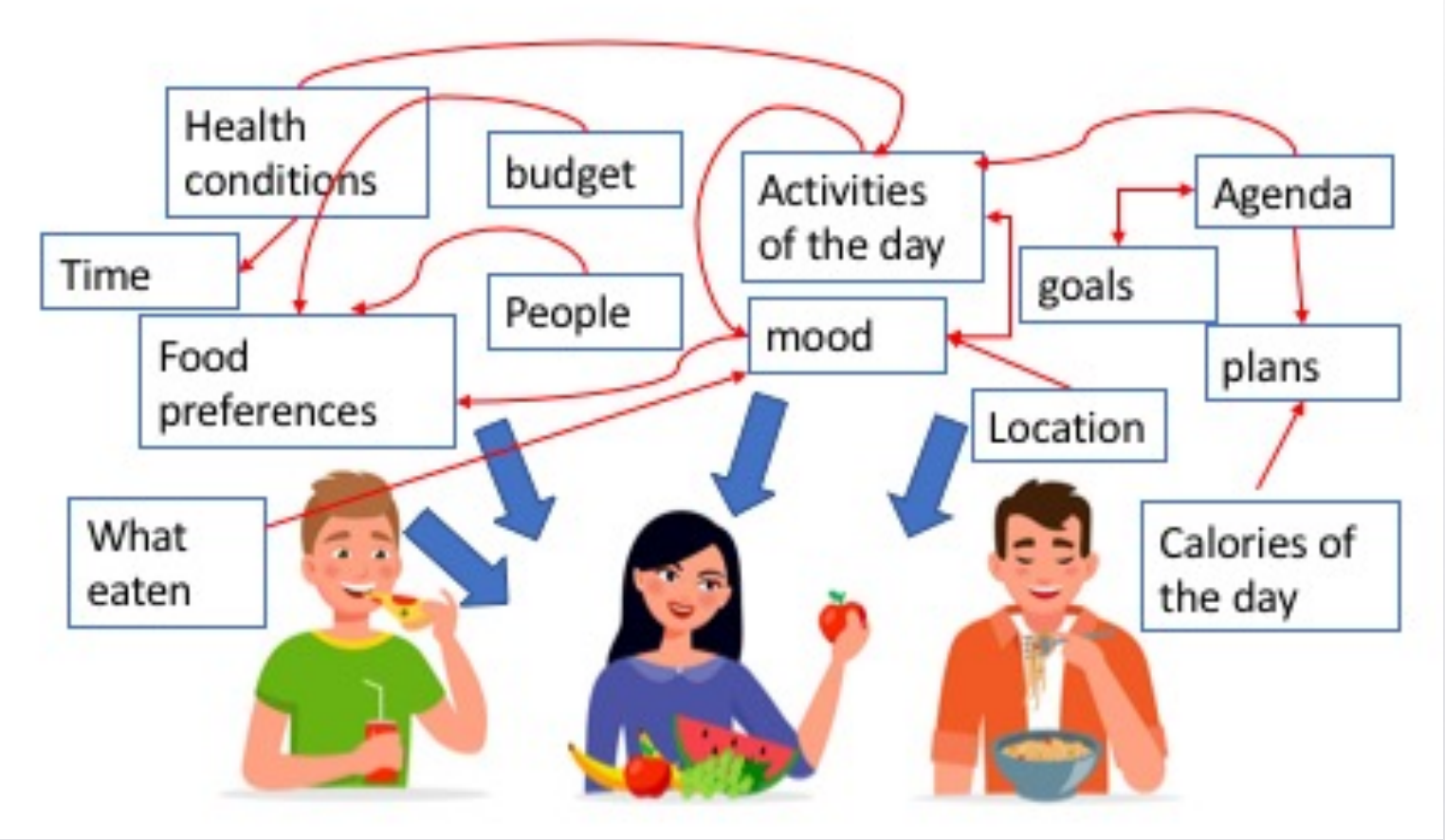


creating a sort of **total, holistic representation of an individual**

Holistic recommendation

- built on the ground of such holistic representation of the user
- which considers:
    - Multiple user features at the same time
    - Features relationships and conflicts
    - Constraints in providing a suggestions
- which can affect the everyday life of a person (what to do, goals to achieve, etc)

- to give suggestions on an aspect in a domain starting from data about multiple user's facets.



Holistic recommendation

- Health recommender
- Food recommender, activity recommender
- Recommender for people with special needs/frailty
  - Considering only preferences cannot be enough to support them in dailylife
  - it should be extremely accurate (a wrong recommendation can cause anger or anxiety)

Open Issues

Even if accurate and useful for users, HORs use large amount of sensitive/ private data (e.g., health data, location data, etc).Thus, **privacy** becomes a fundamental concern.

An **ethical holistic recommender system** must ***be fair, explainable and privacy-preserving, as well as accurate***

Spatial supports for disabilities

Type of spatial support

- Wayfinding
- Information about surrounding

- **Disability-based** (expoiting a disability model, the same for all the users)
- **Profile-based** (exploiting a user model)

Disability-based for visually impaired

- **Input**:
  - Shaking the device
  - vocal messagges
- **Output**:
  - Tell the user her position (name of the street)
  - Describe the sourround
  - Alert with sound, vibration or voice

No personalisation! Only a model of the disability

List of apps

- **Ariadne (iOS):** tells user position and allows her to monitor it while walking, telling street numbers or street names. User can be alerted with a sound, vibration or a voice.
- **Lazzus** help visually impaired people to know what is around them in real time, giving auditive information about places of interest nearby the users
- **Lazarillo:** Using audio messages, Lazarillo will tell user about nearby places, the street user is walking on, street intersections
- **Sendero (iOS & Android):** app that speaks the location, what direction user is facing and what points of interests are around.
- **BlindSquare (iOS):** app that finds location using Apple's GPS then looks up information about the surroundings. When user shakes her device it tell her current address and the venues around her.
- **Get There GPS (Android):** app that tells user where she is and how to get to her destination. the user can ask it to tell her where she is at any time by shaking the device.
- **Around Me (Android):** app that identifies user position and shows a list of the POI and the distance to them

- **Lazus:** an mobile application developed to help visually impaired people to know what is around them. It allows them to explore their surroundings in real time, giving auditive information about places of interest nearby the users. It has two main modes: beam mode, where the user points wherever you want to explore; or 360 mode, to put your mobile in your pocket and use it as an assistant.
- www.lazzus.com
- https://www.youtube.com/watch?v=eKDszs_ncN4)

- **Ariadne** offers the possibility to know the position at any time and monitor it while walking, you can decide to be informed about what changes along the way, street numbers, street names, etc..
- There is also the option to save favorite points and to be alerted, when you approach one of them using sound, vibration, and even voice.
- Allow to explore the map, giving an idea of the conformation of a certain area by tapping the map with their finger. Moving the finger on the map, you can hear the street names and make a mental map of the area.

- http://www.ariadnegps.eu/?lang=eng

- **LazarilloApp is** a specialized GPS app that brings mobility tools for blind people. Using audio messages, Lazarillo tells about nearby places, the street you are walking on, street intersections.
- Like a radio, Lazarillo will announce the places around you while you move.

  The GPS resource is used even if the App is in the background.

- https://www.youtube.com/watch?v=hTrXj3yQQYM

Disability-based for motor disabilities

- **Input**:
  - Crowdsourcing
  - Crowdsensing
- **Output**:
  - Indicates the accessible paths to a places
  - Indicate accessible services in the surroundings (toilets, etc)

No personalisation! Only a model of the disability

Crowdsourcing

Some apps are aimed to collect data about urban accessibility directly from user, focusing mainly on motor disabilities:

- **Axs Map** (https://www.axsmap.com).
- **Wheelmap** (www.wheelmap.org)
- **Liberi di muoversi (**http://www.liberidimuoversi.it/map/)
- **Mapability** (http://www.mapability.org)
- **Wheelmate** (https://www.coloplast.com/products/bladder-bowel/wheelmate/)

They require a community of people willing to participate in data collection

Crowdsensing

Thus, crowdesing solutions have been developed, in order to exploit sensors and GPS capabilities to automatically gather data

- **Path 2.0** [1] is one of the first geo-crowdsensing proposals that allow users to passively contribute routes during their everyday movements, by assuming that these routes can be useful to other users with similar needs.
- **PAM** (Personalized Accessibility Map) [2] is able to combine the general needs of wheelchair users with individual specific preferences to obtain personalized paths.
- **IBM Sidewalks** [3] is a geo-crowdsourcing mobile application that allow users to capture pictures and upload data about relevant aspects of sidewalks, such as steps, holes, etc.

Crowdsensing

- **MEP** (Maps for Easy Paths), a project aimed at providing users with two mobile apps for automatically collecting users' pedestrian routes and visualizing relevant information on accessibility maps respectively [4]
- **mPASS** [5] is able to integrate data from three different sources: i) smartphone sensors, ii) users who voluntarily review urban accessibility information, and iii) official reviews provided by authorities and organizations. MIXED

Wayfindings in limited areas

- The problem of finding accessibile paths in limited areas is being addressed by several universities and colleges all over the world.
- **Way-finder** [6], a system targeted at students and visitors of the University College Cork (Ireland), which supports blind and low-vision people in traditional and mobility training.
- **PAM** application [7] has been developed on the basis of the requirements provided by 20 campuses in US and then tailored to support the students of the University of Pittsburgh in trip planning.
- **UniBS4All** [8], which adopted a Universal Design Approach to Wayfinding and Navigation, first applied to Brescia campus.

Apps for cognitive-impaired people

- No apps specificly designed for people with cognitive disabilities (dementia, down, etc)
- Only some **GPS Trackers** which app allows family members to track each other

No personalisation!

1. Palazzi C. E., Teodori L., Roccetti M. 2010. Path 2.0: A participatory system for the generation of accessible routes. In: Proceedings 2010 IEEE International Conference on Multimedia and Expo. 1707–1711.

2. Karimi H. A., Zhang L., Benner J. G. 2014. Personalized accessibility map (PAM): a novel assisted wayfinding approach for people with disabilities. Annals of GIS 20, 2 (2014), 99–108

3. Shigeno K., Borger S., Gallo D., Herrmann R., Molinaro M., Cardonha C., Koch F., Avegliano P. 2013. Citizen Sensing for Collaborative Construction of Accessibility Maps. In: Proceedings of the 10th International Cross- Disciplinary Conference on Web Accessibility (W4A '13). ACM, New York, NY, USA, Article 24, 2 pages

4. Sara Comai, Emanuele De Bernardi, Matteo Matteucci, Fabio Salice: Maps for Easy Paths (MEP): Enriching Maps with Accessible Paths Using MEP Traces. GOODTECHS 2016: 254-263

5. Catia Prandi, Paola Salomoni, and Silvia Mirri. 2014. mPASS: integrating people sensing and crowdsourcing to map urban accessibility. in *Proceedings of the IEEE 11th Consumer Communications and Networking Conference* (CCNC '14), pp. 591–595, LasVegas, Nev, USA, January 2014.

6. Mehigan T. J., Pitt I. 2012. Harnessing Wireless Technologies for Campus Navigation by Blind Students and Visitors. In Klaus Miesenberger, Arthur Karshmer, Petr Penaz, and Wolfgang Zagler (Eds.), Computers Helping People with Special Needs. Springer Berlin Heidelberg, Berlin, Heidelberg, 67–74.

7. Karimi H. A., Zhang L., Benner J. G. 2013. Personalized Accessibility Maps (PAMs) for Communities with Special Needs. In: Proceedings of the 12th International Conference on Web and Wireless Geographical Information Systems (W2GIS'13). Springer-Verlag, Berlin, Heidelberg, 199–213.

8. Arenghi A., Belometti S., Brignoli F., Fogli D., Gentilin F., Plebani N. 2018. UniBS4All: A Mobile Application for Accessible Wayfinding and Navigation in an Urban University Campus. In: Proceedings of the 4th EAI International Conference on Smart Objects and Technologies for Social Good (Goodtechs '18). ACM, New York, NY, USA, 124-129.

Profile-based support for disabilities

- Personalized systems that create a model of the user and then adapt the services and the interaction to it
- Consider that people with disability are different with different interests, preferences and idiosincrasy
- An Holistic User Model could help in providing more accurate recommendation

Goal	Recommendation of app for people with special needs
Techniques	Ontology for user modeling,
Personalisation:	Yes
Spatial support	no
domain	**E-commerce**

Torres-Carazo M.I., Rodríguez-Fórtiz M.J., Hurtado M.V., Samos J., Espín V. (2014) Architecture of a Mobile App Recommender System for People with Special Needs. In: Hervás R., Lee S., Nugent C., Bravo J. (eds) Ubiquitous Computing and Ambient Intelligence. Personalisation and User Adapted Services. UCAmI 2014. Lecture Notes in Computer Science, vol 8867. Springer, Cham

User modeling wizard	Kurschi et al, 2013
Goal	user modelling wizard that is specific for people with motor disabilities, that adapt the interaction according to motor disability (automatic app configuration according to user needs)
Techniques	Ontology, adapt webpages according to the user's preferences, thus making it easy for the user to achieve his or her goals when accessing a given information. The recommendation algorithm is based on probability that estimate the user's objective (based on past user reading and browsing behaviour) (content-based approach)
Personalisation:	Yes
Spatial support	no
Domain	**Intelligent user interface**

W. Kurschl, M. Augstein, H. Stitz, P. Heumader, and C. Pointner, "A user modelling wizard for people with motor impairments," in Proceedings of International Conference on Advances in Mobile Computing & Multimedia - MoMM13. Association for Computing Machinery (ACM), 2013

Personalized

SOLVE-D	Sohn at al, 2013
Goal	context-sensitive recommendation framework of personalized services for disabled people in smart home environments.
Techniques	Ontologies for representing data, makes recommendations considering the user's profile and his or her context, content-based recommendations
Personalisation:	Yes
Spatial support	Yes (indoor)
domain	**Smart home**

M. Sohn, S. Jeong, and H. J. Lee, "Self-evolved ontology-based service personalization framework for disabled users in smart home environment," in 2013 Seventh International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing. Institute of Electrical & Electronics Engineers (IEEE), jul 2013. [Online].

Personalized

	Batouche et al., 2012
Goal	Recommendation of Travel Plans for **Elderly People** who usually have capacity and health restrictions
Techniques	Semantic Web (ontology for the domain), a mixed approach for recommendation: - Stereotype - Content-based (similarity wrt to previous destinations) - Collaborative (similarity among users)
Personalisation:	Yes, group recommendation
Spatial support	yes
domain	**Turism guide**

B. Batouche, D. Nicolas, H. Ayed, and D. Khadraoui, "Recommendation of travelling plan for elderly people according to their abilities and preferences," in 2012 Fourth International Conference on Computational Aspects of Social Networks (CASoN). Institute of Electrical & Electronics Engineers (IEEE), nov 2012.

Personalized

Maps personalisation

Usually it takes the form of a personalisation of the map

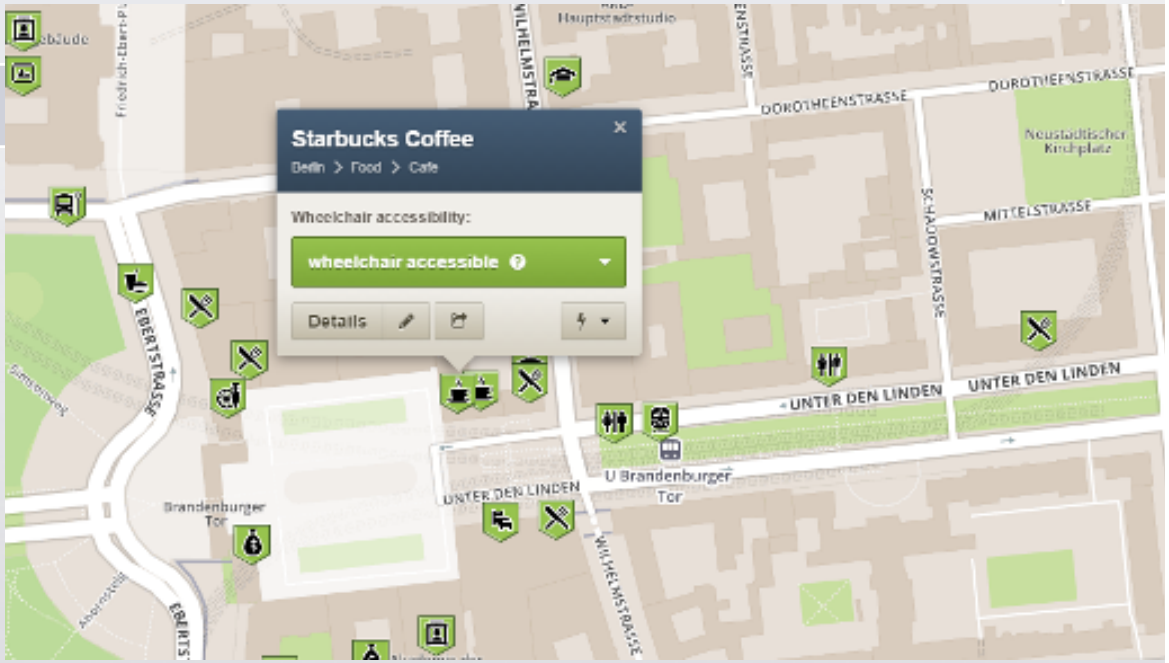
- **Compass** (MacAoidh & Bertolotto, 2007), a GIS application that monitoring of their interaction
- Vulcanos ()
- **Mapper** (Weakliam et al., 2008) generates maps considering users' preferences and context: starting from monitoring user behaviour with maps, the system infers individual and group preferences
- **RecoMap** (Ballatore et al., 2010) calculates a score based on the interest shown by users for specific geographical features.
- **Piuma** (Cena et al, 2018) a personalized interactive urban maps for autism

Maps personalisation

Usually it takes the form of a personalisation of the map, generating maps considering users' preferences and context: starting from monitoring user behaviour with maps, the system infers individual and group preferences

- **Compass** (MacAoidh & Bertolotto, 2007)
- **Mapper** (Weakliam et al., 2008)
- **RecoMap** (Ballatore et al., 2010)
- **Vulcanos** (Gomez, 2019)
- **Piuma** (Cena et al, 2018)

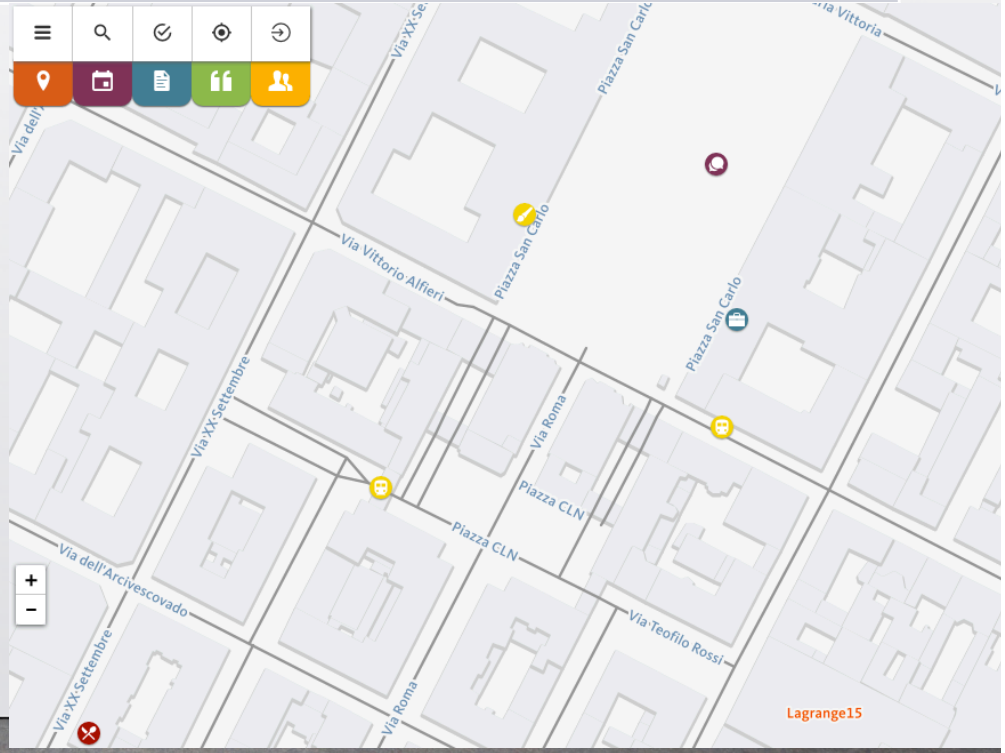
Vulcanus 2.0	Gomes, 2016
Goal	recommends accessibility resources to the user (parking places, parking ramps, elevators, sound signals, notifications in Braille, etc) , considering information of the user's context and profile (all disability but use case on motor disability)
Techniques	Ontologies, Analysis of previsous trails (resources that user consumes in the day, with the context where the user was while using the resource), user similarity
Personalisation:	Yes
Spatial support	yes
domain	**LBS**



Personalized

GOMES CARDOSO, Ismael, et al. Vulcanus 2.0: a recommender system for accessibility. *CLEI Electronic Journal*, 2016, 19.1: 6-6.

Piuma	Cena et al, 2018
Goal	Promote the urban mobility of ASD people
Techniques	Personalized POIs suggestions, crowdmapping, personalized routing
Personalisation:	Yes, provide personalised suggestions of POIS and of routes
Spatial support	yes
domain	LBS-service



Cena, Rapp, Mattutino, Personalized Spatial Support for People with Autism Spectrum Disorder, UMAP extended proceedings 2018

(Personalized) spatial support for Autism

Austism Spectrum Disorder

- **Autism spectrum**, also known as **autism spectrum disorder** (**ASD**), is a range of mental disorders. It includes autism and Asperger syndrome.
- Symptoms are typically recognized between one and two years of age.
- .

Special needs

- Autistic people show difficulty in social relations
- They show restricted, repetitive patterns of behavior, interests or activities.
- They have a weak central coherence
- They find safe in the routine
- Specific spatial needs

- Long term issues may include difficulties in performing daily tasks, creating and keeping relationships, and maintaining a job

Technologies for autism

Children: medical model promotes early intervention targeting school-aged i ndividuals (Kientz et al,2013, Boucenna et al, 2014):

- Frauenberger et al. (2016) develop smart objects designed from and for their idiosyncratic perspective.
- **vSked** (Hirano et al. (2010)): an interactive and collaborative visual scheduling system for supporting primary school classroom activities
- **EnhancedTouch** (Suzuki et al. (2016): a bracelet wearable device that can measure human-human touch and provide visual feedback, to facilitate physical contact
- **PEACE** (Participatory Evaluation with Autistic ChildrEn) Spiel et al. (2017) an approach to include autistic children in dedicated evaluation phases through the co-definition of goals and methods, joint processes of data gathering and cointerpretation of findings.

Technologies for autism

Adult: Focus on social communication skills, emotion management and social interaction:

- **SocialMirror** (Hong et al. (2012), a device connected to an online social network that allows autistic adults to seek advice from a trusted network of family, friends and professionals
- **Clasp** (Simm et al, 2014), a tactile anxiety management, communication and peer support tool developed with, by and for adults with high ASD.
- **SayWat** (Boyd et al., 2016), a wearable assistive technology that provides feedback to adults with autism about their prosody during face-to-face conversations.
- **Snap** (Simm et al., 2016) a digital stretch wristband that collects interaction for later reflection and the self-management of anxiety
- **HygieneHelpe**r (Hayes & Hosaflook, 2013) supports teens and young adults in developing skills for independent living by tracking and monitoring progress on hygiene routines, and prompting feedback through a virtual coach.

Personalisation and autism

Personalized technologies for autism are still very rare (Simm et al., 2016). Most of the applications regard the educational domain (Mintz, 2012):

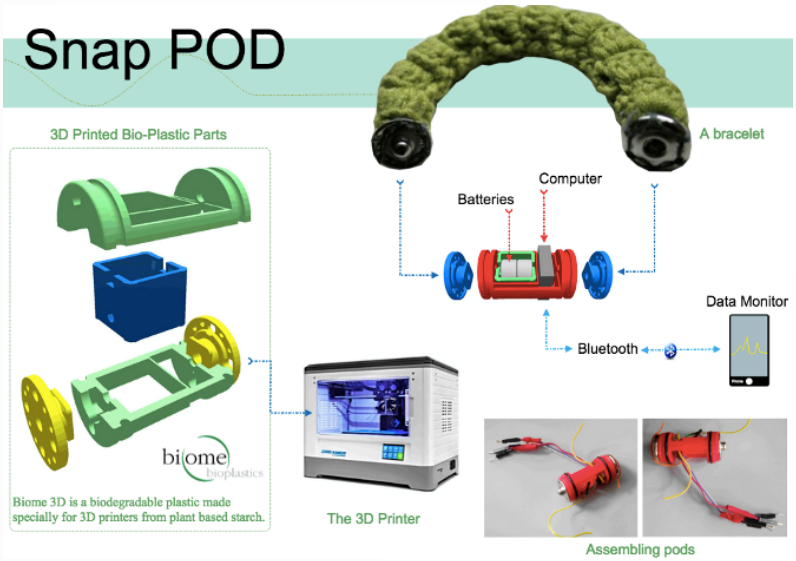
- in (Judy, 2012) a personalized e-learning system that exploits semantic web technologies is proposed.
- Social Mirror: (Hong, 2012), proposed a social networking aiming at supporting the independence of young adults with autism by providing recommendations and suggestions
- (Khosla, 2015) reported in the results of a nine-month trial investigating the impact of an adaptive humanoid robot able to change its behavior (voice tone, expressions, sound effects) on the ground of the activity patterns and the preferences of the participants

.

Systems for ASD

name	personalized	Spatial support	domain
Snap (Sim et al., 2016)			Anxiety detection
Hands (Mints et al., 2012)			elearning
Montes, 2012			elearning
Judy at al, 2012	#		elearning
Social Mirror (Hong 2012)	#		Social interaction training
Lucy (Khosla et al, 2015)	#	#	Home assistance
AUTISM&UNI (Garcia, 2014)		#	Indoor wayfinding
PIUMA (cena, 2018)	#	#	Outdoor wayfinding

Snap	Sim et all, 2016
Goal	Design a wearable device to track level of anxiety
Techniques	Snap is a customizable hand-made digital stretch wristband that records interactions for later reflection.
Personalisation:	Yes, in the design (3D printing)
Spatial support	no
Domain	Self-management of health



Simm, Ferrario, Gradinar, Tavares Smith, Forshaw, Smith, Whittle. 2016. Anxiety and Autism: Towards Personalized Digital Health. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (CHI '16). ACM, New York, NY, USA, 1270-1281.

HANDS	Minz and Aagaard, 2012
Goal	(Helping Autism Diagnosed young people Navigate and Develop Socially) Design a system to support them to develop ADS social skills and self-management skills
Techniques	a web based flexible toolkit that teachers use to develop specific support and intervention sequences specific to the need of each child. These sequences consist of a series of linked screens, each of which can include customizable text, images, video and sound.
Personalisation:	Yes, customized "personal trainer"
Spatial support	no
domain	elearning

Joseph Mintz and Morten Aagaard . 2012. The application of persuasive technology to educational settings. Educational Technology Research and Development 60(3) 483-499

	Judy et al, 2012
Goal	An adaptive e-learning system based on soft semantic web technologies can be developed to teach the students with autism
Techniques	ontologies to describe learning materials, annotation schemas and ontology of services.
Personalisation:	Yes, Individual Education Plan (IEP) based on goals and objectives that are unique to the individual
Spatial support	no
domain	elearning

M. V. Judy, U. Krishnakumar and Hari Narayanan. 2012. Constructing a personalized e-learning system for students with autism based on soft semantic web technologies. 2012 IEEE International Conference on Technology Enhanced Education (ICTEE), Kerala, 2012, pp. 1-5. doi: 10.1109/ICTEE.2012.6208625

Lucy	Khosla et al, 2015
Goal	To study the best communication modalities to trail ADS people (quiz) and remember activities in the calendar
Techniques	The integration of service delivery includes human-like communication attributes like voice, emotive expressions, head and body motion in dancing style to generate positive emotional engagement of the person with autism and breaking technology barriers.
Personalisation:	Yes, adaptation of the interaction + provide personalized contents (favourite music, songs..)
Spatial support	no
domain	Home-base care assistive robot

Khosla, R., Nguyen, K., & Chu, M. T. (2015, November). Service personalisation of assistive robot for autism care. In *IECON 2015-41st Annual Conference of the IEEE Industrial Electronics Society* (pp. 002088-002093). IEEE.S

	Montes Garcia et al, 2016
Goal	Support student in higher education + rassicuring on privacy preservation
Techniques	Wibaf + wordpress
Personalisation:	Yes, Adaptive le learning objects
Spatial support	no
domain	learning

Alejandro Montes García, Natalia Stash, Marc Fabri, Paul De Bra, George H. L. Fletcher, Mykola Pechenizkiy. 2016. Adaptive web-based educational application for autistic students. Published in: Extended Proceedings of Hypertext 2016, Halifax, Canada.

Social Mirror	Hong et al., 2012
Goal	supporting the independence of young adults with autism
Techniques	social network
Personalisation:	Yes, provide personalized information tailored to the current situation the individual is facing (e.g. personalized help reminder: to o encourage the individual to seek advice)
Spatial support	indoor
domain	Independent living

Hwajung Hong, Jennifer G. Kim, Gregory D. Abowd, and Rosa I. Arriaga. 2012. Designing a social network to support the independence of young adults with autism. In Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work (CSCW '12). ACM, New York, NY, USA, 627-636

AUTISM&UNI	Garcia, Stash and De Bra, 2015
Goal	To support autistic users @ TUE university
Techniques	framework for adative web interaction
Personalisation:	Yes, adaptation of the presentation of the content to the cognitive level of the user
Spatial support	Yes, People with autism find it difficult to find their way around big areas such as a university campus and suffer from anxiety when they do not know where to go. They need to know when and where the next lesson is going to be, how to reach the library, the cafeteria, registration offices, etc. They need very concrete pointers, not a site overview to explore
domain	University education

- **Garcia, Stash and De Bra*, 2015, Adaptive Applications to Assist Students with Autism in Succeeding in Higher Education*, UMAP 2015**
- Alejandro Montes García, Natalia Stash, Marc Fabri, Paul De Bra, George H. L. Fletcher, Mykola Pechenizkiy. 2016. Adaptive web-based educational application for autistic students. Published in: Extended Proceedings of Hypertext 2016, Halifax, Canada

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domain	LBS-service

Cena, Rapp, Mattutino, Personalized Spatial Support for People with Autism Spectrum Disorder, UMAP extended proceedings 2018

Personalized Interactive Urban Maps for Autistic Spectrum Disorder

PROJECT

http://piuma.di.unito.it

- Ongoing project (May 2017-May 2020)
- mix of personalisation, crowdsourced and IOT for making a City accessible to autistic people
- Founded by:

PIUMA

TEAM

- **Department of Computer Science**
- **Department of Psychology**
- **Local healthcare agency**

UNIVERSITA
DEGLI STUDI
DI TORINO

ASL
CITTÀ DI TORINO

Starting problems

- Lack of aid for autistic adults
- Supports mainly of a communicative / cognitive nature, no spatial support
- Maps for physical, non-cognitive disabilities

Goals

- Understand how autistic people represent urban space

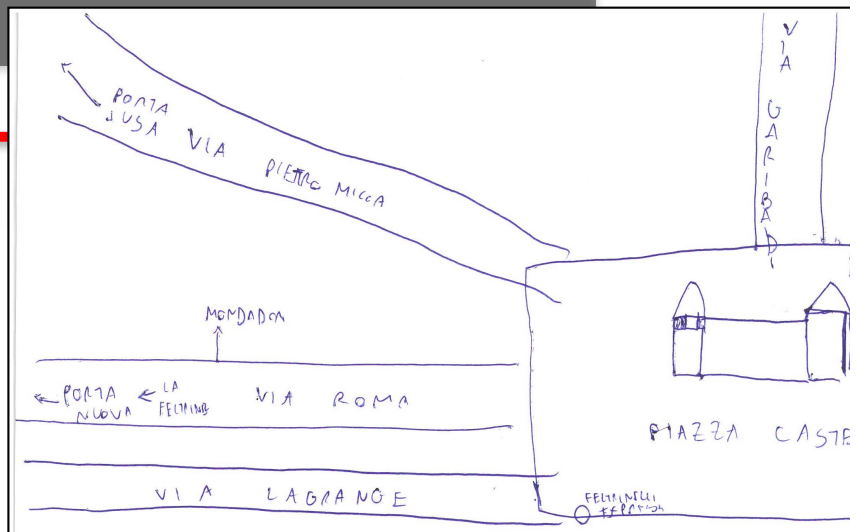
- Support them in their movements in space, helping them in managing daily life and anxiety

Goals

Understanding how autistic people represent urban space

- 1.1 spatial needs
- 1.2 sensoriality

Interviews, questionnaires, focus groups, participatory design sessions by psychologists → USER REQUIREMENTS



Rapp, A., Cena, F., Castaldo, R., Keller, R., & Tirassa, M. (2018). Designing technology for spatial needs: Routines, control and social competences of people with autism. *International Journal of Human-Computer Studies*, *120*, 49-65.

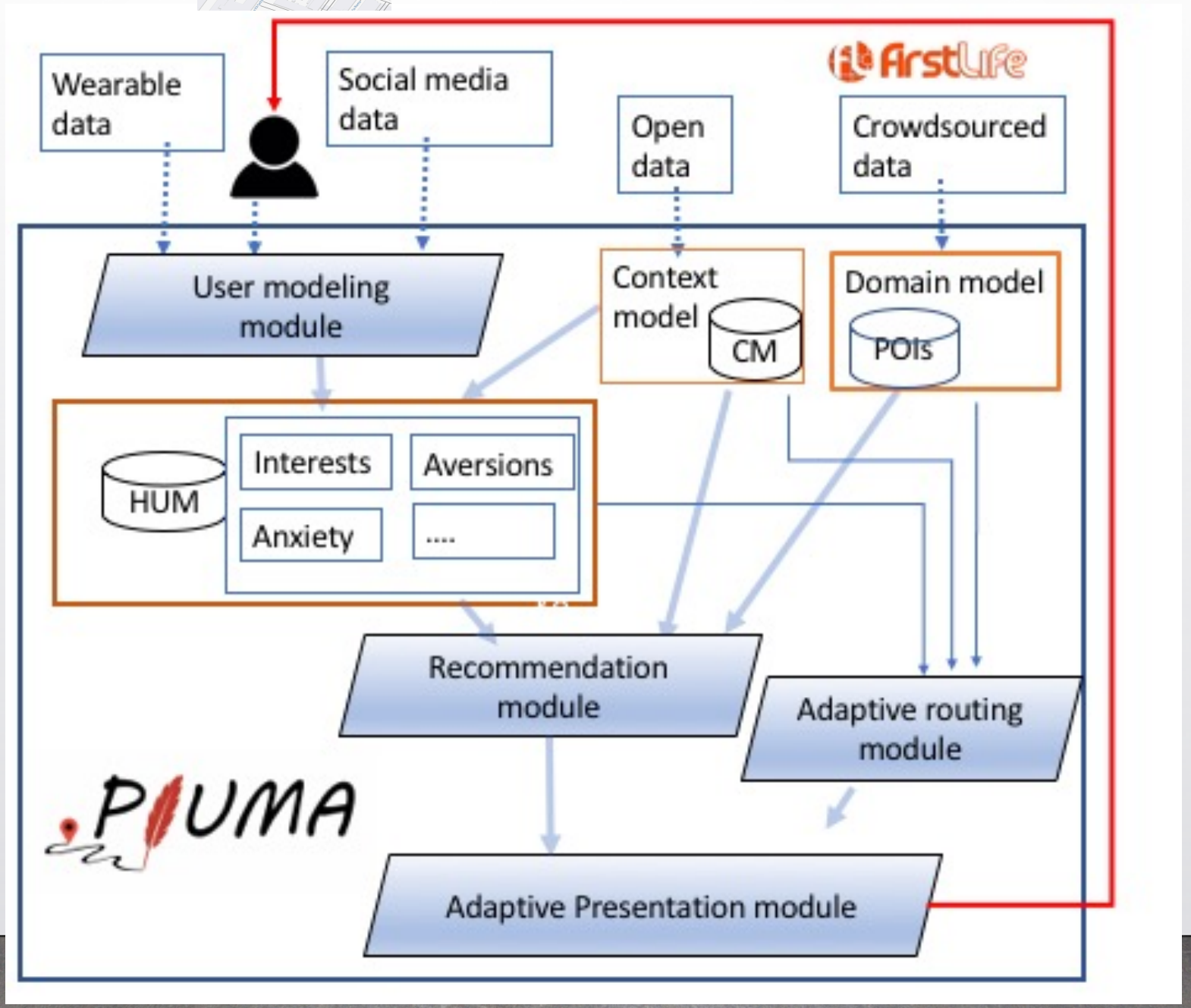
Requisiti emersi

Goal 2

Design a urban maps that is

1. **crowdsourced**: annotated by users with sensory characteristics of places
2. **assistive**: able to support people in space movements through intelligent safe routing based on their level of anxiety
3. **personalized**: able to suggest safe POIs based on preferences, aversions of the user towards sensory characteristics (recommender system)

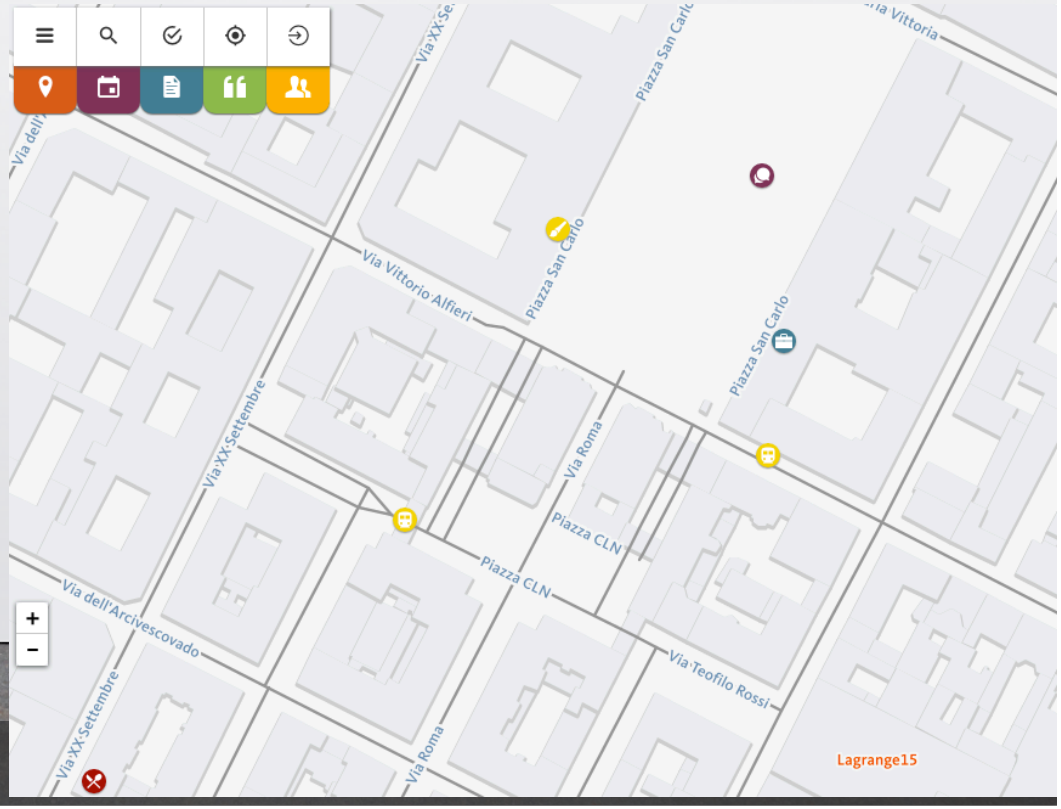
Rapp, Cena, Mattutino, Boella, Schifanella, Grassi. Holistic User Models for Cognitive Disabilities: Personalized Tools for Supporting People with Autism in the City. UMAP 2018 workshop

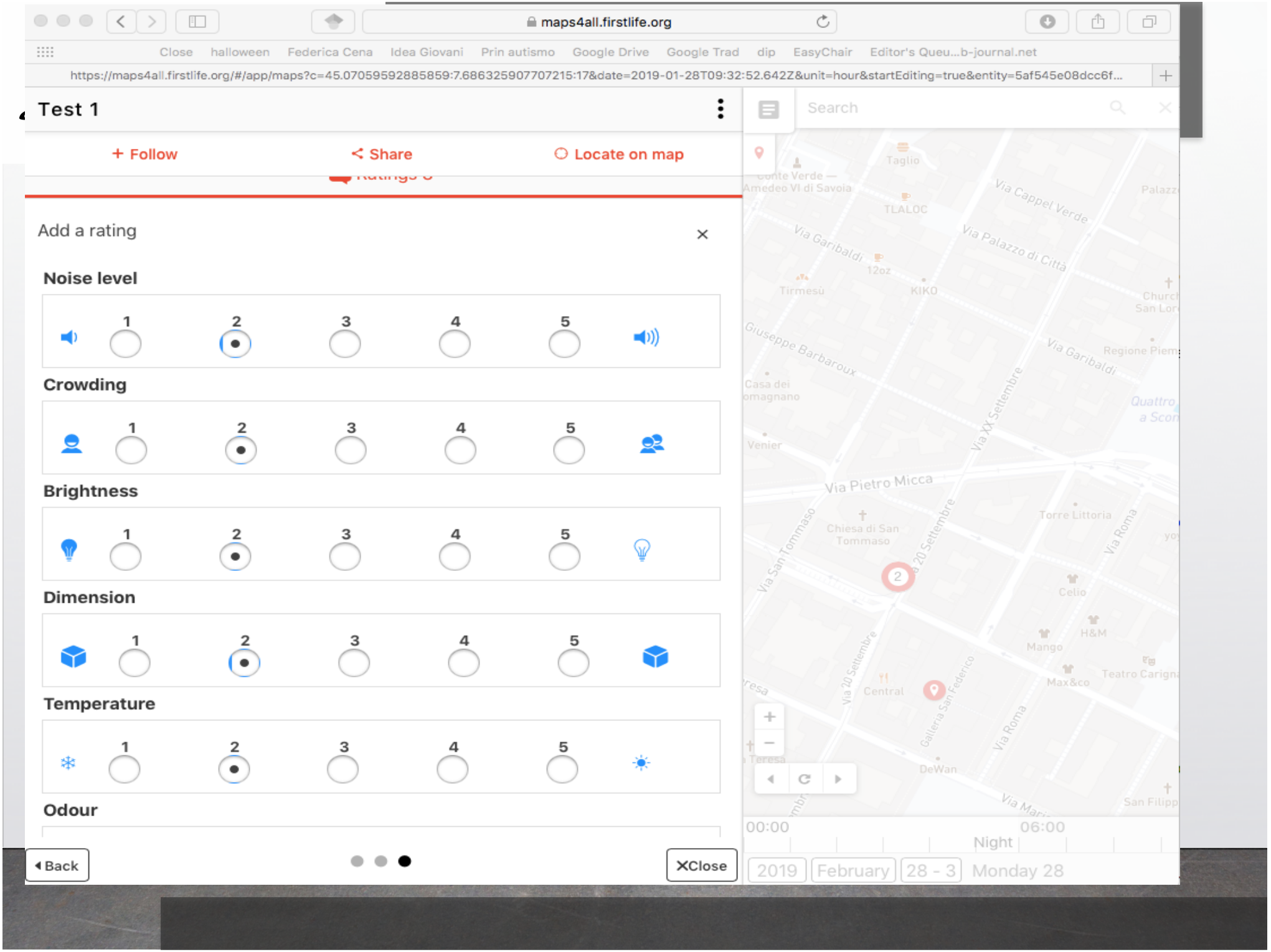

FirstLife
Wearable data
Social media data
Open data
Crowdsourced data
User modeling module
Context model
CM
Domain model
POIs
HUM
Interests
Aversions
Anxiety
....
Recommendation module
Adaptive routing module
PUMA
Adaptive Presentation module

2.1 Crowdsourced map

- Populated by comments, reviews, suggestions about places/events/activities that are ASD “safe”
- Particular emphasis on sensorial features of a place (noise level; temperature; brightness..)

https://maps4all.firstlife.org

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Giuseppe Barbaroux
Via Garibaldi
Via XX Settembre
Via Pietro Micca
Via San Tommaso
Via 20 Settembre
Via Roma
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2.2 Personalized map

- Based on a **holistic user model**:
  - **Preferences** (declared by users or inferred from social networks)
  - **Aversions** with respect to the sensorial features (declared or inferred from the evaluations made in the crowdsensed map)
  - **Anxiety level** (detected by wearables devices or inferred from context such as breakdown of routine, traffic, whether or by smartphone sensors (wandering))
  - **Cognitive abilities**
  - **Spatial habits**
  - **Causes of anxiety and coping strategies**
  - **Other diseases**

2.2 Personalized map

- Starting from the crowdsoursed data, and taking into account the Holistic User Model, it recommends:
  - “safe” POIs/activities to calm her down
  - “safe” paths to reach them

- PUSH or PULL modality:
  - The user asks for help
  - The system proactively provides suggestions:
    - In case of high anxiety level of the user
    - In case of problem where she is (car crash, traffic, bus deviations, bad weather conditions..)

2.2 Personalized map

Cascade hybrid approach (Burke, 2002):

1. *Content-based (Pazzani, Billsus, 2007)*: used inferred preferences on places categories
2. *Collaborative filtering (*Schafer et al, 2003*)*: we consider aversions in similarity calculation (Pearson correlation) and then suggested POIS that similar users liked the most
3. Context-awareness: POIs in the nearby (with a radius of 500 meters) and reachable by means of a “path safe”

Cena, Rapp, Mattutino, Personalized Spatial Support for People with Autism Spectrum Disorder, UMAP extended proceedings 2018

2.2 Personalized map: routing

- **Safe PATH**:
- route to reach a destination calculated on the fly based on the user's characteristics, avoiding roads with featueres that may annoy the user (very noisy and crowded way such as throught open markets, shopping roads..)

- Based on tags and annotation from OpenStreetMap and from Open Data of Turin Municipality

To do

- **Field evaluation of the system** (non only usability, but how it can cause a behavioural change → increase spatial autonomy of persons
- **Online population campaign** to have more data about places

Future work

- **Adaptation of the map interface** (vocal, textual, graphic, 3D) on the basis of the person's cognitive capability (orientation problems, difficulty in understanding verbal instructions) and possibly cognitive overload (eg level of attention at the moment)
- **Training for social behavior** (i.e. going to the post office, hospital, supermarket, etc.) with different tools (game, Virtual Reality, Augmented Reality)

1. Rapp, A., Cena, F., Castaldo, R., Keller, R., & Tirassa, M. (2018). Designing technology for spatial needs: Routines, control and social competences of people with autism. *Int. Journal of Human-Computer Studies*, *120*, 49-65.
2. Rapp, Cena, Boella, Antonini, Calafiore, Buccoliero, Tirassa, Keller, Castaldo, Brighenti: Interactive Urban Maps for People with Autism Spectrum Disorder. CHI Extended Abstracts 2017: 1987-1992
3. Cena, Rapp, Tirassa, Boella, Calafiore, Keller: Personalized interactive urban maps for autism: enhancing accessibility to urban environments for people with autism spectrum disorder. UbiComp/ISWC Adjunct 2017: 9-12
4. Rapp, Cena, Tirassa, Boella, Calafiore, Keller. Tracking personal movements in urban environments: personalized maps for people with autism spectrum disorder.UbiComp/ISWC Adjunct 2017: 883-886
5. Rapp, Cena, Boella, Antonini, Calafiore, Buccoliero, Tirassa 2017 Interactive Maps for Cognitive Disabilities, UbiComp/ISWC Adjunct
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