Reasoning, Personalization, Adaptation on the Web

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Outline

- Know your teacher (briefly introducing myself)
- Motivation to this lesson: why should you care about adaptation, personalization and reasoning?
- Technicalities
  - User modeling (concepts)
  - Adaptation by reasoning (mostly reasoning about actions and change)
    - Agents
    - Curriculum sequencing / planning
    - Web services / interaction protocols
- Lunch!

Who am I?

Researcher
Ph.D. in Cognitive Sciences
background: Artificial intelligence/Soft Computing

- machine learning (symbolic and neural)
- Agents that acquire a behaviour from experience
- reasoning about actions/change
- Adaptation by means of reasoning -> Semantic Web

Applicative fields:
- robotics (control function approximation)
- image representation and understanding
- curriculum sequencing / e-learning
- web services

Artificial Intelligence / Soft Computing

the dream of most who work in AI: to see a robot, that you programmed, that really shows an intelligent behavior

problem: robots tend to fall down the stairs and get broken ...

software agents are much less expensive! So why not doing something that goes on the web? Is it that different?

A user (maybe a program) aims at finding a web page. The user describes -by keywords- what desired to a search engine (e.g. Google) that finds the proper resources and returns the links to the user. The key: powerful indexing mechanisms

Nowadays

A user (maybe a program) aims at the execution of a task which involves the use of information/services accessible over the web. The user executes a program, that finds the proper resources and invokes them, in a way that fulfills the user's goals

General Framework

Resources are annotated by terms that belong to shared ontologies. Descriptions can be "understood" by programs, that perform intelligent queries, and reason about them

Problem

the information on the web is human-oriented
Scenario
A Comp. Sci. Department information service

Query
Find the telephone numbers of researchers

But telephone numbers associated to people not to what they do!! (e.g. A. Turing 34567)

If the system knows that researchers are human beings and that telephone numbers are associated to human beings

Then the system will retrieve the desired information

Ontologies and Inferences
(example of intelligent info retrieval)

Ontologies and Inferences
(is-a and part-of)

Relations
ontologies usually define shared vocabularies, often the terms defined by an ontology are related by means of is-a or part-of relations

is-a
A researcher is a person

part-of
A CPU is a part of a computer

What is a computer?
A conjunction should be expressed

Some other scenarios

Scenario:
Gigi wants to read the news
he connects to the web site of his favourite newspaper

Provider:
the program that retrieves and maybe composes the information to be presented

Product:
the composed page

Possible forms of adaptation/personalization:
at the level of information retrieval (by provider) at the level of information presentation (by provider or by browser)

Technique:
user modeling
Example 2

Scenario:
Lilla wants to buy a computer on-line
she connects to an on-line computer shop

Provider:
the program that interacts with the user for
understanding the needs and proposing a product

Product:
the assembled computer

Possible forms of adaptation/personalization:
at the level of computer assembly (by provider)
at the level of information presentation
(by provider or by browser)

Technique:
goal-driven
reasoning
(+ user mod.)

Example 3

Scenario:
An artificial agent is delegated the task of making a
reservation at a cinema where they show a given
movie in a given town; the user does not want to leave
his/her telephone number

Provider:
the cinema booking service

Product:
the interaction with the provider + the reservation

Possible forms of adaptation/personalization:
at the level of interaction (by the agent)
(The search involves also dealing with a registry)

Technique:
reasoning about
behaviour

Example 4

Scenario:
An artificial agent is delegated the task of making a
reservation at a restaurant and then at a cinema
where they show a given movie in a given town; the
user does not want to leave his/her telephone
number

Provider:
the restaurant and the cinema booking services

Product:
the interaction with the provider + the reservation

Possible forms of adaptation/personalization:
at the level of interaction (by the agent)
at the level of composition (by the agent)
(The search involves also dealing with a registry)

Technique:
behaviour
composition +
reason about
behaviour

Difficult tasks!

They require adaptation

Adaptation:
The ability to alter so as to fit for a new use
produce personalized solutions according to:
- The user's characteristics
- The user's goal
- To fit a process specification
Difficult tasks!

Resource annotation is not enough

- Adaptation is mostly a form of reasoning
- Knowledge is important:
  - Info about the user (‘s goal)
  - Info about the domain
  - Constraints
- Models

Taking into account the characteristics of the user ... user models

User models

90% of research on adaptation and personalization on the Web is based on user models

A user model is a description of those characteristics of the user that are relevant to the decision process that leads to the selection and the presentation of the information (e.g. Education, age, personal taste, ...)

Classic approach

the user model is initialized by explicitly asking the user to answer a questionnaire, and is refined connection after connection. Often the initial model is empty

Information retrieval

The user model must be described according to a vocabulary; the same holds for the resources that are to be selected/presented to the user; the system must know the vocabulary as well.
Each prototype has associated a presentation style that rules the way in which the information will be shown to the user. Style sheets are commonly used to this aim. Often different descriptions are directly associated to each resource.

Example 1
(working on the web)
In a virtual shop, the same good is presented in different ways to different users:

User 1: young, loves computers and science-fiction
Description will contain many technical details, comparison with other products, many numbers and acronyms.

User 2: middle-age, loves painting and nature
Description will be at high-level, design and eco-compatibility of the good will be underlined.

Example 2
(educational hypermedia)
Users (called "learners") have access to a set of resources (documents, software) that they should read. Such resources are arranged in a hypermedia, through which they "navigate".

Problem: many kinds of users! Different backgrounds!

One step look-ahead strategy: whatever the current position, show only the links, that lead to documents about topics, that the user can understand.

New links are "opened" according to:
- Which pages have been visited
- Which tests have been passed

Often links are not hidden, they are just marked in a different way:
- red = stop, you cannot understand this page
- green = go ahead, you are suggested to read this page
Example 2
(educational hypermedia)

- A decision process occurs
- How to decide if a link is to be shown?
- The technique is curriculum sequencing and consists in:
  1) To describe the contents of documents by annotating the learning resources by the terms of an ontology (such terms are called in many ways: knowledge items, knowledge entities, competences, ...)
  2) to capture in some formal way the relations between the knowledge items
  3) To use such descriptions and knowledge about the user (user model + knowledge about what he/she already read) to decide which other topics he/she can understand
  4) Bayesian networks are used to this purpose

Some links
- L. Ardissono and A. Goy, Tailoring the Interaction With Users in Web stores, User Modeling and User-Adapted Interaction, 10(4):251-303

Learning models
The idea is to induce a user model by observing the behaviour of a user
- Off-line learning: a training set of examples is gathered while interacting with the user and it is used to learn a model
- Lazy learning: the model is learnt/updated while making recommendations

Social behavior
(offline vs. online)
- Collaborative filtering
- User models can be inferred by studying the behaviour of a population
  - e.g. By means of unsupervised neural networks
  - K-means and Self-Organizing Maps
Clustering

Is the task of identifying groups of similar individuals out of a set of learning instances. The obtained groups can be used for classifying new individuals based on a similarity measure.

K-means clustering algorithm

- Choose K initial cluster centers
- Assign all data points to the closest cluster
- Recalculate the cluster center by applying the following formula to each center coordinate

\[ \sum_{i=1}^{N} W_{ij} \]

- If the new centers differ from the previous ones go back to the beginning

Other approaches exploit SELF-ORGANIZING MAPS (or Kohonen's maps) to perform the same task. They are an unsupervised neural network model.

Some example systems

WEBSOM: documents are organized in a two-dimensional map based on a description of their contents

LOGSOM: organizes web pages on a SOM according to user navigation patterns

Learning data: obtained from server log files
Problems

- Neural networks are mathematical tools for function approximation, their inputs are vectors of numbers.
- Web page content is described in a symbolic way by the terms from some ontology.
- How to turn a discrete, symbolic domain in a continuous, numeric domain?

Problems of collaborative filtering

- Early-rater problem: collaborative filtering has no way to suggest a new resource (it has not been considered by users yet).
- Sparsity problem: if the number of users with respect to the volume of information in the system user models are not reliable.
- Users whose taste is different than the norm are not modeled.

Some links

- B. Mobasher, R. Cooley, J. Srivastava, Automatic personalization based on web mining, communications of the ACM 43(8), 2000
- M. Perkowitz, O. Etzioni, Adaptive sites, learning from user access patterns, proc. of WWW6, 1997

Not only user models
When UM do not work well 1

User models are refined according to the behaviour of the user and capture his/her general preferences. They are “past-oriented”, in some situations this may be inconvenient.

Example

news portal: usually Pino checks for sport news but today he heard of a terrible accident and would like to immediately find info about it.

When UM do not work well 2

User models are meaningful only if users visit a web site frequently; this is not always the case. Often web site visits are “task-oriented”, the reasoning task should focus on helping the user in satisfying his/her goals.

Example

buying a PC: find out what kind of use will be done of the PC (server? Playing games? Browsing the web? Esthetic purposes?)

Recommender systems

When UM do not work well 3

The user may be a piece of software (e.g. a software agent). This may be the case of “web services”, hardware or software resources, accessible via the web, that can be automatically retrieved, invoked, composed, etc.

Example

organize a visit to Aussois: find a train, find a hotel, check out the weather forecast, etc.

Are these forms of personalization?

- News portal: personalize information selection w.r.t. the user’s goal
- Computer shop: adapt the interaction with the user according to his/her interests
- Organize trip to Aussois: compose a set of softwares (web services, developed independently) so to accomplish a task that respects the constraints posed by the user

In all these cases:

personalization is an outcome of processing we will how it can be an outcome of reasoning
What do we need?

A semantic layer associated to resources (documents, software, ... whatever)

Reasoning techniques for performing retrieval, sequencing, composition, ...

Is it necessary to develop new techniques?
No

What we'll see next

Two main cases:
- educational application domain
  - selection
  - curriculum sequencing
  - validation
- web services
  - selection
  - personalization of the interaction with a w.s.
  - composition

Educational Framework

Learning resources as actions

Let us interpret a learning resource LR as an action:
- LR can be executed if the user has some competence C
- by executing LR the user will acquire competence G

C and G are expressed in the terms given by an ontology
the system state is a representation of the user (supposed) knowledge (its initial knowledge, augmented step by step)
The systems adopts the user goal of acquiring some expertise (learning goal) and builds a plan for achieving it
no probability is to be defined
Learning resources as actions

- prerequisites
- processes
- concurrency
- mutual exclusion
- effects
- deadlock
- deadlock avoidance
- Ontology terms

Resources explicitly annotated by ontology terms!

Important!

The description of the resources is not extracted (e.g., by text processing techniques) as it often happens nowadays.

- It is added to the resources by the creators.
- It is a description at the level of knowledge, given in terms of a shared vocabulary, that can be used by automatic systems.

Reasoning about learning resources

Selection can be based on a (knowledge level) description of what a resource supplies/teaches.

- It can further be constrained by the system state.

User knows:
- processes
- concurrency
- deadlock

Wants to learn:
- Module A
- Module B

Same as ...

Curriculum sequencing

We have mentioned educational application domains and curriculum sequencing: i.e., the task of defining good reading paths in a hyperspace of learning resources.

In Adaptive Hypermedia a one-step approach is followed:

- At any time a Bayesian network decides which learning resources the user can read with profit; it disables access to the others.
- A learning goal is defined: the user will arrive to the goal by different paths, depending on the initial knowledge, and on personal taste.

But I can also ...
Reason about learning resources
sequencing

Module B can be selected only if the user knows also something about Mutual Exclusion.

The system can search for a second module that teaches the missing competence.

User knows

Deadlock avoidance

Want to learn

Processes concurrency

Module X

Module B

Multi-step sequencing: planning