Topics in User Modelling in Interactive Information Retrieval

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Schedule

- Changes will appear on the course webpage
- 04.09.19 Lecture 1: Introduction to IR and IIR
- 11.09.19 Lecture 2: Cognitive modelling
- 25.09.19 Deadline for topic selection (title + 3 papers min.)
- 09.10.19 Presentation of chosen topic (5 mins, 5 slides)
- 30.10.19 Feedback session
- 20.11.19 Final presentations (20 mins, 20 slides) - if necessary
- 27.11.19 Final presentations (20 mins, 20 slides)
- 11.12.19 Deadline for final paper submission
Recap 1: IR evaluation
Recap 2: IIR evaluation

Research Questions, Hypotheses, and Theory. Explicit research questions were found in 19.3% of the studies (n = 29), explicit hypothesis were found in 10.7% (n = 16) of the studies, and both a research question and a hypothesis were found in 4.7% of the studies (n = 7). In 65.3% (n = 98) of the studies, there was neither an explicitly stated research question nor hypothesis.

Recap 2: IIR evaluation

statistics, while 9% \((n = 11)\) did not provide any indication of which type of analysis was used, despite claiming statistically significant results or presenting probability values. Almost all the analyses were performed variable-by-variable and were conducted to compare the systems. Only a small percentage of articles described statistical analyses that attempted to model performance using multiple input variables \((n = 6, 5\%)\).
Why cognitive models?

• Cognitive models relate models of psychological processes to behavioral data

• A cognitive model should be viewed as a hypothesis for an experiment

• We use data to identify which model has the best empirical support (model selection)

• We can perform evaluation on the basis of model parameters instead of raw data
Essay structure

• Essay will have 3 sections:

  • **An IIR component (or search task)** (e.g. ranking, relevance feedback, implicit relevance feedback) - what does it do? how is it implemented? how is its effectiveness validated?

  • **A cognitive process** (e.g. categorisation, decision making, implicit learning) - what does it study? describe the model, what type of experiment is used to gather data?

  • **Cognitive modelling in IIR** (e.g. modelling relevance feedback as a categorisation process) - sketch an experimental design, what old results can be replicated? what new results will we get?
Essay structure

• Two approaches:

  • **Correlation:** Gain an understanding of IIR component/search task + cognitive model ⇒ propose hypothesis relating the two + experiment to test hypothesis

  • **Integrative:** Gain a deep understanding of IIR component/search task + cognitive model ⇒ propose an experiment to fit the model itself
Modeling Life as Cognitive Info-Computation

Authors: Gordana Dodig-Crnkovic  Venue: arXiv Computer Science  Date: 28/01/2014

This article presents a naturalist approach to cognition understood as a network of info-computational, autopoeitic processes in living systems. It provides a conceptual framework for the unified view of cognition as evolved from the simplest to the most complex organisms, based on new empirical and theoretical results. It addresses three fundamental questions: what cognition is, how cognition works and what cognition does at different levels of complexity of living organisms. By explicating the info-computational character of cognition, its evolution, agent-dependency and generative mechanisms we can better understand its life-sustaining and life-propagating role. The info-computational approach contributes to rethinking cognition as a process of natural computation in living beings that can be applied for cognitive computation in artificial systems.

Reusing processes and documenting processes: toward an integrated framework

Authors: Françoise Détrienne, Jean-François Rouet, Jean-Marie Burkhardt, Catherine Deleuze-Dordron  Venue: arXiv Computer Science  Date: 04/12/2006

This paper presents a cognitive typology of reuse processes, and a cognitive typology of documenting processes. Empirical studies on design with reuse and on software documenting provide evidence for a generalized cognitive model. First, these studies emphasize the cyclical nature of design activities in which software engineers use and generate documentation and reuse code.
Theory of Categorization

• Can do we determine if something is the member of a category?
  • Aristotelian model
  • Prototype models
  • Exemplar models
Aristotelian categorization model

- Classical view of categories: Plato + **Aristotle** (The Categories)

- Categories defined by list of features shared by all category members

- Properties are necessary conditions of category membership: entity must have **all features** to be a member of category

- Categories are strictly defined, mutually exclusive and collectively exhaustive

- Members are equal; no entity is more of that category than another

[https://plato.stanford.edu/entries/aristotle-categories/]
Aristotelian categorization model

- Criticisms of Aristotelian categorization:
  - Entities can belong to a category, without sharing all features
  - Some entities are better exemplars of categories than others (degrees of membership)
  - Membership not strictly binary
Prototype models

- Category judgments are made by comparing an object to a **prototype** (summary, average) in terms of **similarity**

- Prototype need not be real, purpose is to define membership by similarity - could emphasise features that distinguish between categories

- Categorises are not "out there" in the world, but rooted in human experience
Prototype models

• Criticisms of Prototype models:
  
  • Information can be lost, i.e. it is difficult to model:
    
    • differences in category size
    
    • differences in category variability
    
    • correlations between features
    
    • multimodal distributions
    
    • outliers!
Exemplar models

- Category judgments are made by comparing an object to all members of category (so-called exemplars) in terms of similarity.

- Similarities are aggregated to make a categorization decision.

  **Note similarities:**

  - 1 exemplar/category = prototype
  - Low variability of exemplars = little information loss with prototype
Categorization Example

• Categories A and B (above and below \(x=y\))

• Two features:
  • position of line
  • height of box

• What is the relative importance of features for categorization?

Generalized Context Model (GCM)

- Exemplar model of categorization

- Category representation is just a list of category members (exemplars)

- Assume simple case (2 features per exemplar, 2 categories):
  - We need a distance function (w is the attentional weight):
    \[ d_{ij} = w|p_{i1} - p_{j1}| + (1-w)|p_{i2} - p_{j2}| \]
  - ...and a similarity function (c scales the drop-off in similarity with increasing distance):
    \[ s_{ij} = \exp(-c \cdot d_{ij}) \]

Similarity function

\[ d_{ij} = w|p_{i1} - p_{j1}| + (1-w)|p_{i2} - p_{j2}| \]
\[ s_{ij} = \exp(-c \cdot d_{ij}) \]
\[ c = 0.5 \]
\[ w = 0.5 \]
Generalized Context Model (GCM)

- Probability of classifying exemplar $i$ into category $A$ (as opposed to category $B$) is:

$$P(R_i = A | i) = \frac{\sum_{j \in A} s_{ij}}{\sum_{j \in A} s_{ij} + \sum_{j \in B} s_{ij}}$$

Participants used both features, but line position was slightly more important.
Generalized Context Model (GCM)

- Bayesian GCM with repeated measures:

Essay idea 1: for relevance feedback, how does the attentional weight distribution ($w_k$) vary between:
- systems?
- user groups?
- search tasks?

Generalized Context Model (GCM)

- Bayesian GCM with repeated measures and a latent-mixture including contamination:

Essay idea 2: for relevance feedback, how does the proportion of contamination users change between:
- systems?
- user groups?
- search tasks?

Generalized Context Model (GCM)

- Probability of classifying exemplar \( i \) into category \( A \) is (alternate version):

\[
P(R_i = A | i) = \frac{\left( \sum_{j \in A} s_{ij} \right)^\gamma}{\left( \sum_{j \in A} s_{ij} \right)^\gamma + \left( \sum_{j \in B} s_{ij} \right)^\gamma}
\]

- \( \gamma = 1 \): same response as original GCM
- \( \gamma < 1 \): responses are increasingly random
- \( \gamma > 1 \): responses are increasingly deterministic

Essay idea 3: for relevance feedback, how does \( \gamma \) differ between lookup and exploratory search?


Essay suggestions

- **IIR interface components:**
  - ranking
  - relevance feedback
  - implicit relevance feedback

- **Search tasks:**
  - Lookup/exploratory search

- **Cognitive models:**
  - **Decision making**
    - Categorization processes (prototype vs exemplar)
    - Signal detection theory (discriminability vs bias)
    - Diffusion decision processes (berry-picking)
  - **Other**
    - Working memory, perceptual speed, risk taking, implicit learning, etc.

I will add starting points to many of these topics on the course webpage!
Next deadline...

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