(Pro-)Seminar: Cognitive Modeling

16.10.2017

Marco Ragni ragni@informatik.uni-freiburg.de
Nicolas Riesterer riestern@tf.uni-freiburg.de
Lukas Elflein elfleinl@informatik.uni-freiburg.de

Introduction

Cognitive Modeling is a research discipline at the boundary of psychology and natural sciences such as computer science, which aims at explaining human behavior on a computational level. Apart from matching the observable properties of human cognition as closely as possible, cognitive modeling is invested in the advancement of a general understanding of cognition. Instead of relying solely on abstract mathematical formalization such as neural networks, models are supposed to offer a means of interpretation while striving for functional equivalence to the mental processes.

Syllogisms are a core problem of the domain of human reasoning. They consist of tasks where two premises containing a quantifier (*all*, *some*, *some ... not*, *none*), a subject (e.g. *dentist*), and an object (e.g. *gardeners*), each, are presented. Depending on the task, a conclusion, again consisting of a quantifier, a subject, and an object, needs to be generated or verified:

All dentists are gardeners.
Some gardeners are bikers.

$\therefore$ Some dentists are bikers.

Introduced by Aristotle, syllogisms have been an integral part of the research centered around understanding the human mind. In contemporary psychology, there exist at least twelve theories claiming to explain human syllogistic reasoning. However, due to significant differences in their assumptions and theoretical foundation, direct comparisons proved to be immensely difficult. Currently, it is unclear how this set of candidates compares and, correspondingly, which of the underlying assumptions are the most promising.

Multinomial Processing Tree (MPT) models are a family of cognitive models for problems with categorical outcomes that is based on the multinomial distribution. By reparameterizing the multinomial distribution using a latent tree structure consisting of assumptions about related mental subprocesses, human cognition can be modeled in a well-defined, structured manner. Apart from being easy to use, MPT models have the advantage of being defined on a meta-level to traditional computational models. Instead of directly specifying computational routines, they make claims about the interaction of mental *processes* which can be arbitrarily precise.

The goal of this seminar is to investigate the potential of the contemporary psychological theories of syllogistic reasoning. This encompasses the formalization of a selected theory as an MPT, the analysis of its performance on given data, and the optimization of the model. As a result, the seminar will end with a comparison of the current state of the art.

General Information

1. Study the introductory articles:
   (a) Khemlani, S., & Johnson-Laird, P. N. (2012). Theories of the syllogism: A meta-analysis.
   (b) Singmann, H., & Kellen, D. (2013). MPTinR: Analysis of multinomial processing tree models in R.
   (c) Riefer, D. M., & Batchelder, W. H. (1988). Multinomial modeling and the measurement of cognitive processes.
2. Register in HiSinOne for the seminar and send us your topic preferences at the same time.
3. Implement the theory as a MPT
   - Familiarize yourself with the repository: https://gkigit.informatik.uni-freiburg.de/teaching.coco.seminar/2017-ws-syllog
   - Get the experimental data "khemlani-2012.csv" from the repository.
   - Implement your MPT in the Easy Format (see 1b).
   - Analyse the performance of your model on the Khemlani data set (AIC, BIC, FIA, see 1b))
   - Optimize your MPT with regard to BIC
4. Create a presentation (20 min per student)
   - Explain the theory with example syllogisms
   - Describe the theory on an algorithmic level
   - Develop a flowchart describing the core processes
   - Describe your MPT on an algorithmic level
   - List all additional assumptions required for your MPT
   - Discuss possible improvements of your model
   - Pro/Cons of the theory
   - Think about the scope of your theory: Can it predict single participant answers?

- You can assume everyone knows about syllogisms and MPTs
- You should be able to demonstrate your theory with any given syllogism and answer questions from the audience.
- Your presentation must be a single PDF document.

5. Write a summary of your model (roughly 3 pages) in LaTeX.

At the end of the seminar, we will be able to rank the quality of the syllogistic theories based on the performance of your original and optimized models.

Additional notes regarding the presentation

- There is a presentation on 'How to give a Presentation': http://ais.informatik.uni-freiburg.de/teaching/ws16/seminar_robotnav/GivingAPresentation.pdf.
- There is also a lecture where you can learn about giving presentations: http://gki.informatik.uni-freiburg.de/teaching/ws1718/prosem/index_de.html

Timetable

Presence during the Seminar is mandatory. Submissions handed in after the deadlines will not be accepted.

Event	Date	Address
First Meeting	16.10.17, 12:00	02-017, Building 101
Registration	16.-25.10.17	hisinone.uni-freiburg.de
Topic Preferences	16.-25.10.17	riestern@tf.uni-freiburg.de
Topic Assignments	03.11.17	-
Presentations & Model Submission	17.12.17	riestern@tf.uni-freiburg.de
Improved MPT Model and Summary	14.01.18	riestern@tf.uni-freiburg.de
Seminar	20./21.1.18, 09:00-17:00	TBA

General background information on MPTs/statistics

- My Process Models Book by Jeff Rouder `http://pcl.missouri.edu/jeff/sites/pcl.missouri.edu.jeff/files/b1_0.pdf`

Topics (2 Students each)

Topic 1: Atmosphere Theory

- Woodworth, R. S., & Sells, S. B. (1935). An atmosphere effect in formal syllogistic reasoning. Journal of Experimental Psychology, 18(4), 451.
- Begg, I., & Denny, J. P. (1969). Empirical reconciliation of atmosphere and conversion interpretations of syllogistic reasoning errors. Journal of Experimental Psychology, 81(2), 351.
- Revlis, R. (1975). Two models of syllogistic reasoning: Feature selection and conversion. Journal of Verbal Learning and Verbal Behavior, 14(2), 180-195.
- Revlin, R., Leirer, V., Yopp, H., & Yopp, R. (1980). The belief-bias effect in formal reasoning: The influence of knowledge on logic. Memory & Cognition, 8(6), 584-592.

Topic 2: Matching Theory

- Wetherick, N. E., & Gilhooly, K. J. (1995). Atmosphere, matching, and logic in syllogistic reasoning. Current Psychology, 14(3), 169-178.

Topic 3: Illicit Conversion

- Chapman, L. J., & Chapman, J. P. (1959). Atmosphere effect re-examined. Journal of experimental psychology, 58(3), 220.
- Revlis, R. (1975). Two models of syllogistic reasoning: Feature selection and conversion. Journal of Verbal Learning and Verbal Behavior, 14(2), 180-195.

Topic 4: PHM

- Chater, N., & Oaksford, M. (1999). The probability heuristics model of syllogistic reasoning. Cognitive psychology, 38(2), 191-258.

Topic 5: PSYCOP

- Rips, L. J. (1994). The psychology of proof: Deductive reasoning in human thinking. Mit Press.

Topic 6: Verbal Models

- Polk, T. A., & Newell, A. (1995). Deduction as verbal reasoning. Psychological Review, 102(3), 533.

Topic 7: Mental Models

- Johnson-Laird, P. N., & Steedman, M. (1978). The psychology of syllogisms. Cognitive psychology, 10(1), 64-99.
- Bucciarelli, M., & Johnson-Laird, P. N. (1999). Strategies in syllogistic reasoning. Cognitive Science, 23(3), 247-303.