TECHNISCHE UNIVERSITÄT DARMSTADT

Thesis (B.Sc. / M.Sc.)
Combining Rate Distortion Theory and Bayesian Modelling

Fachbereich 18
Elektrotechnik und Informationstechnik
Bioinspirierte Kommunikationssysteme

Department 18
Electrical Engineering and Information Technology
Bioinspired Communication Systems

Prof. Dr. Heinz Koeppl
Head of lab

In order to understand how humans process information, David Marr proposed looking at this problem at three different levels: The computational (what is the problem), algorithmic (how is it solved), and implementational (how is the solution implemented) level [1]. While neuroscientists often start at the last level and first try to understand the "hardware" of the brain to reveal insights about its functioning, cognitive scientists often begin their investigation at the fist level. When starting at the fist level, one first defines what the actual problem is that a human is trying to solve and derives its optimal solution. Most of the time, when looking at experimental data, humans deviate from the derived optimal solution. In the past, this led to conclusions that humans simply are not rational and many heuristics were proposed which humans seem to use instead of solving the actual task. For many problems, however, it could later be shown that by adapting the task to incorporate all the uncertainties and limitations of humans, they indeed solved the task near-optimally.

It is often sufficient to build a Bayesian model of the task that contains all uncertainties of human perception and action. However, when limited computation resources must be taken into account, it is not straight forward to include these limitations into the model. As a solution, either additional noise for the computation was added to the Bayesian model or the system was modelled using rate distortion theory [2]. In the latter case, the whole system from stimulus to action is modelled as an optimization problem subject to limited channel capacity based on information theory, however, ignoring where all other uncertainties come from.

In this project, we are going to investigate how one can combine the ideas of rate distortion theory and Bayesian modelling to have informed Bayesian models with limited information channels. The prospective student should be interested in Cognitive Science (ideally has taken General Psychology class in studium generale) and has already basic knowledge of Bayesian statistics and Python programming.

For further information, please contact Matthias Schultheis.

Matthias Schultheis
Project supervisor

Rundeturmstraße 12
64283 Darmstadt

Phone: +49 6151 16 - 57 253
matthias.schultheis@bcs.tu-darmstadt.de
https://www.bcs.tu-darmstadt.de

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References

[1] David Marr. Vision: A computational investigation into the human representation and processing of visual information, henry holt and co. *Inc., New York, NY*, 2(4.2), 1982.

[2] Toby Berger. Rate-distortion theory. *Wiley Encyclopedia of Telecommunications*, 2003.