

Presentation of Bayesian Decision Making Toolbox (BDM)

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The Bayesian Decision Making Toolbox is a next generation of software tools developed at the department of adaptive systems. As the name suggests, its main purpose is to serve development of algorithms for Bayesian Decision making and their implementation in practical applications.

Design considerations The toolbox is designed using object oriented approach, where mathematical objects—such as probability density functions (pdfs), and estimators—are represented by corresponding software classes [2]. These objects form a tree-like structure, where the root classes represent the most general forms of the mathematical object and each inheritance level represents a specific specialization of the object. For example, the most general class for probability density functions is called `pdf`. The exponential family of pdfs is a special case, with specific properties, therefore, its software class `eEF` is inherited from `pdf` which it extends by appropriate methods. The Gamma density is a special case of the exponential family pdf, hence it is inherited from `eEF`.

Implementation The toolbox is implemented in two parts: (i) C++ library, and (ii) Matlab toolbox. The library consists of basic classes of decision-making: pdfs, Bayesian estimators, decision strategy designers. These classes are created from user-specified information in hierarchical way. Numerical computation is implemented through the IT++ library, which maps fast routines (e.g. MKL) into clean C++ API which is reminiscent of Matlab syntax. The Matlab toolbox consists of mex files of prepared scenarios for the use of the classes from the library. These scenarios work as follows: (i) they read user configuration and create the requested decision-making objects, (ii) a predefined algorithm is performed on these objects. For example, the `estimator` scenario is a general algorithm of sequential Bayesian estimation (Bayesian filtering). All scenarios can be also compiled as standalone application.

Open Development Model The toolbox (and the library) is developed as an open-source project with homepage: <http://mys.utia.cas.cz:1800/trac/bdm>. The code is available under the terms of GNU General Public License (GPL) allows to use code from other GPL software projects (e.g. R language). This license entitles anyone to modify and distribute the code under the condition that the changes are also available under this license. The project is managed on-line via open-source system Trac. Anyone is allowed to create a ticket (bug report or feedback) and discuss development of the toolbox. Furthermore, simulations and algorithms published in journal papers or conferences are maintained within the project so that the published results can be reproduced and examined publicly.

What is Implemented The basis of Bayesian calculus is algebra on pdfs. Many specific pdfs are implemented with methods for evaluation of their values and moments. Special purpose classes representing the chain rule of pdfs, or the ratio of pdfs are also available. The Bayes rule is implements for a range of approximations, e.g. Mixtures of exponential family members (EM and QB algorithms), Bayesian filtering (Kalman, particle and marginalized particle filters). Advanced algorithms for merging of fragmental pdfs are also available for various approximations. Various algorithms from Mixtools [1] are being ported to the new system.

We believe that open nature of development and availability of the code for multiple-platforms are sufficient motivators for interested readers to try the toolbox and provide feedback to the authors.

References

- [1] P. Nedoma, M. Kárný, T.V. Guy, I. Nagy, and J. Böhm. *Mixtools (Program)*. ÚTIA AV ČR, Prague, 2003.
- [2] V. Šmídl. *Software analysis of Bayesian distributed dynamic decision making*. PhD thesis, Západočeská Univerzita Plzeň, 2005.

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