Traffic Toolbox

Ing. Rudolf Matoušek
Department of Signal Processig
Institute of Information Theory and Automation
Czech Academy of Science

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Abstract

The article should introduce the Traffic Toolbox which was developed as a part of a Diploma Thesis on the Czech Technical University, Faculty of Transportation Sciences. The toolbox implements Bayesian probability prediction based on the RMGS information filter. The concept allows to use the toolbox in a rich variety of signal processing applications.

1 Introduction

The work was motivated by the incredible traffic situation in Prague. The traffic control demands accurative traffic flow predictions at least 3 data scans ahead. The data signal is very noisy and it is quite often affected by an error. The mathematic model is not known and it even changes during a few day periods. A small changes can be recognized during longer time periond. The presumptions show that the data prediction is really complicated.

2 Algorithms

The situation described above demands a system which is robust and is able to dynamically change the mathematical model. Bayesian probability theory with hypothesis testing offers such properties. The robustness is achieved by implementation of the RLS based information filter by the RMGS one.

The RMGS filter is based on the RLS. The information matrix is decomposed by the numerically robust LD decomposition. It produces the lower triangular, diagonal and upper triangular matrices. The algorithm uses only one triangular and the diagonal matrix which decreases time consumptions during the computation. The algorithm has a special property called nesting. It means that a bigger order filter includes filters of lower orders. In special mathematical model cases, it allows to reduce algorithm complexity by creating a modular filter system.

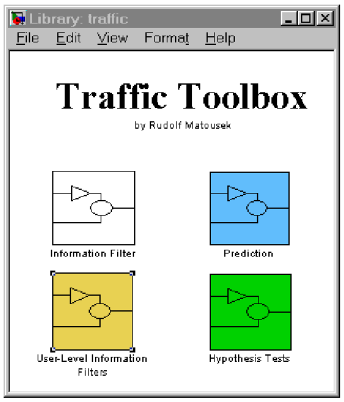
The whole prediction system is created by a set of RMGS information filters, by a set of prediction blocks and by the Bayesian hypothesis testing block. Information filters provides the necessary data to the Bayesian hypothesis testing block. It computes probabilities of each parameter estimate. The parameters are used to system output prediction which is computed by predictors. These are connected by model structure to according information filters. The best prediction is then computed by a suitable algorithm. The toolbox allows to choose the most probable result or to compute the Bayesian mixed result as the sum of the system prediction weighted by the estimated probabilities.

3 Implementation

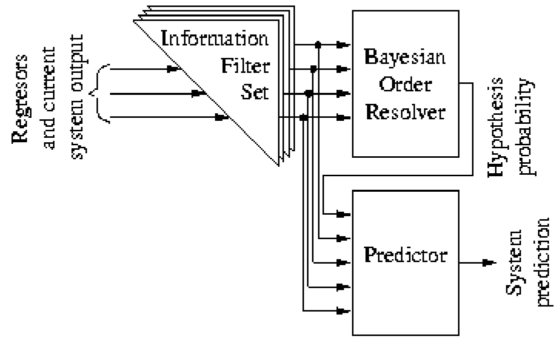
The Traffic Toolbox is shown on figure 1(a). It is divided into four parts. The first provides a set of modular information filters. The second is a set of predictiors. A set of hypothesis testing block is provided to choose the optimal mathematics model in the third part. The last part provides some often used blocks.

3.1 Information Filter Set

On figure 2(a) can be seen the structure of the RMGS information filter. It is composed from three parts. The left triangular part is the basic block. It reads the first regression variable. The center part adds additional regression variables to the system model. The right part computes forward prediction errors and the needed data for the Bayesian hypothesis testing. It also yields data to prediction blocks.



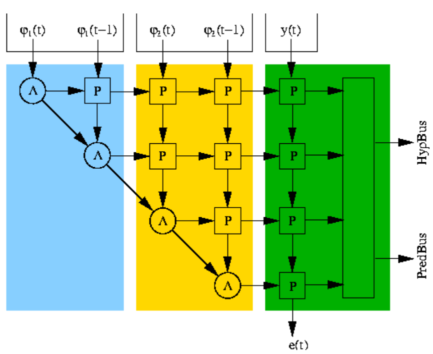
(a) Toolbox window



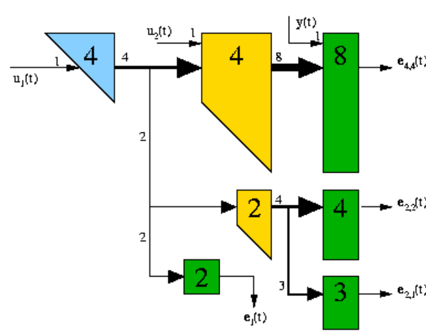
(b) Prediction structure

Figure 1: Traffic Toolbox

The modularity and the nesting can be used to create more information filters on the same base with reduced performance demands. It is shown on figure 2(b). The first regression variable is common for all filters. It has the 4th order. According to the nesting property, the RMGS filter holds all data of lower orders. So the block can provide data of the 2nd order. By adding the right block it creates the first filter. The filter related to the second hypothesis has one additional regressor of the 4th order. The third and the fourth filter are build again on the reduced first filter. They have common the second regressor. It is common for the third filter of the 2nd order and for the fourth of the 1st order. Such filter net decreases the computational complexity about 40%.



(a) QRD scheme



(b) Nesting

Figure 2: Modular RMGS information filter

3.2 Hypothesis Testing Set

The right mathematical model must be recognized from the set of possible models. The task is solbed by the Bayesian hypothesis testing block. It provides directly the hypothesis probability.

The Bayesian hypothesis testing block provides a vector of probabilities of each model. The most probable estimate can be choosen from the set by a special block included in the toolbox. The Bayesian mixed prediction is implemented by another special prediction block.

3.3 Prediction Set

The RMGS algorithm does not provide system parameters directly, so parcor coeficients and the least-squares remainder are used instead. A special structure of the information filter allows to predict the system output with these values. Supposing the fact that the parameters are constant in a short time period, the system prediction can be computed by fixing the parcor coeficients and the least-squares remainder and by creating a new regressor from the current system input and the past output.

The toolbox provides two prediction block and a block for input creation. The first prediction block is suitable for systems where the model set is known but it is switched during time. The predictor provides the most probable prediction. For systems with unknown structure is better to use the Bayesian mixed prediction which provides the prediction error with a lower variation. The first predictor computes just one prediction while the other one has to compute all predictions and then the result.

Each information filter has to have one input creation block. It produces the current system input for the predictor.

3.4 User blocks

The toolbox provides some often used blocks prepared to use. These are created by basic building blocks. It can be used for example for searching for possible mathematic models. The block mask sets all common parameters which decreases the simulation time.

4 Applications

The Traffic Toolbox was originally developed to predict traffic flow in general situatios. An engeneer can perform experiments to choose a suitable prediction model set in a very fast and comfortable way.

The toolbox can be utilized also in other areas than traffic control. It can perform predictions on almost any time series. The hypothesis testing feature allows to use the toolbox to recognize error states of devices with a known structure. The source code allows to use toolbox algorithms without simulink for example to port an algorithm to an embedded signal processor.

5 Conclusions

The Traffic Toolbox is now in version 0.92. Blocks are fixed and validated. Still, there are some new features which should be added to the feature list(RTW support, database connection, data acquisition etc.).

The new versions of the toolbox will be developed in cooperation between the Faculty of Transportation Sciences of CTU and the Department of Signal Processing of UTIA as a teaching project.

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Contact

Ing. Rudolf Matoušek
Ústav Informace a Automatizace, ČSAV
Pod vodárenskou věží 4
P.O. Box 18
180 00 Praha 8

email: matousek@utia.cas.cz
phone: +420-2-6605 2264
fax: +420-2-6605 2511
www: http://www.utia.cas.cz/ZS