Setting of Covariance for Kalman Filter

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In many big cities, traffic congestion extends far beyond city boundaries. Prague, the capitol of the Czech Republic, is no exception to the rule. The people are willing to pay a high cost commuting by cars (time, travel cost, increased possibility of accidents...). The the building of new streets is not usually possible in cities with the historical districts or expensive and built-up land. The second solution is to increase the capacity of the traffic network by the traffic flow control. This control is based on changing of parameters of the signal lscheme to influence the intersections capacities and to make green waves.

The basic principle of the traffic control, designed in our department, is based on minimization of the total sum of queue lengths on all intersection arms in a microregion [3]. Some streets in the microregion are equipped by detectors that measure the intensities (amounts of unit vehicles passing a detector during a per time unit) and occupancies (proportions of sample period, during which the detector is being activated by the vehicles). The queue lengths are immeasurable quantities and so it is necessary to estimate them.

The traffic system can be described by a linear state space model where the state includes the unmeasured queue lengths [1]. For this case, it is possible to estimate queue lengths using the Kalman filter (KF) [2].The state transition matrix includes the unknown parameters that can not be determined from physical relations and so they need to be estimated too. The need of the current estimation of the state and the model parameters is solved by the suitable nonlinear estimation methods, in our case Sigma Point Kalman Filters (SPKF) [5]. This method gives the better estimates and it is more general than using the KF [4]. The both ways (selected linear and nonlinear estimation methods) need the good prior setting of state and measurement covariance matrix to give the better estimates. The value of covariance matrix shows the accuracy of the model or the measurement and our trust to the obtain data.

More over, the traffic variables (input and output intesities, occupancies, etc.) are measured asynchronous to the cycle lengths that increases the uncertainty of the model and the need of the right prior setting of covariances.

This paper aims to the off-line prior setting of the covariance matrices for the KF and the SPKF filters. The traffic nature of variables allow us to expect that in the similar days we can make the same corresponding daily course. For obtaining the typical daily course, the spline approximation is suitable. The prior setting of the covariance matrix is made by the deviation of the actual and typical daily courses. The results of experiments show that the covariance matrices are not diagonal as we have supposed before.

The good prior setting of the covariance matrix is important for the better estimate of the queue lengths during the day, especially in peak-hour when the big changes in traffic variables can be observed.

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