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Approximate propagation of normal distributions for stochastic optimal control of nonsmooth systems

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We present a method for the approximate propagation of mean and covariance of a probability distribution through ordinary differential equations (ODE) with discontinuous right-hand side. For piecewise affine systems, a normalization of the propagated probability distribution at every time step allows us to analytically compute the expectation integrals of the mean and covariance dynamics while explicitly taking into account the discontinuity. This leads to a natural smoothing of the discontinuity such that for relevant levels of uncertainty the resulting ODE can be integrated directly with standard schemes and it is neither necessary to prespecify the switching sequence nor to use a switch detection method. We then show how this result can be employed in the more general case of piecewise smooth functions based on a structure preserving linearization scheme. The resulting dynamics can be straightforwardly used within standard formulations of stochastic optimal control problems with chance constraints.

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