Stochastic Systems Lab

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Asynchronous Stochastic Approximation: Stability and Convergence

- Consider a system comprising n processors each of which updates a parameter component using a stochastic approximation scheme
- At the end of this computation, each processor passes this information to all other processors. This information reaches the other processors with a certain delay that can be random
- Each processor performs updates using its own local clock and with the most recent information on updates it has about the other processors
- Borkar and Meyn have developed some easily verifiable stability conditions for synchronous stochastic approximation algorithms with no delays
- Our work develops such conditions for the case of asynchronous stochastic updates with delays as described above

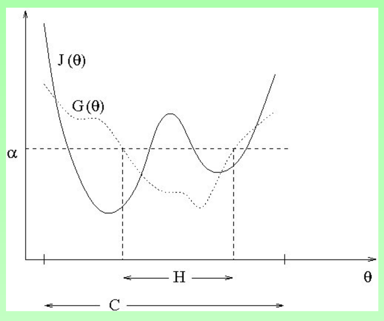
Reference:

- [1] S.Bhatnagar, The Borkar-Meyn Theorem for Asynchronous Stochastic Approximations, Systems and Control Letters, Vol. 60, pp. 472-478, 2011.

Actor-Critic for Constrained Markov Decision Processes

- We consider the problem of control subject to inequality constraints for both discounted cost and long-run average cost criteria. We incorporate function approximation in both the objective and constraint functions resulting in a corresponding constrained parameter optimization problem. The general problem has the following form:

$$\begin{aligned} \min \quad & J(\theta) \\ \text{s.t} \quad & G_i(\theta) \leq \alpha_i, i = 1, \ldots, N \end{aligned}$$



- The objective function $J(\theta)$ and the constraint functions $G_i(\theta)$, $i = 1, \ldots, N$ are either both long-run average costs or else discounted cost functions
- We develop the first actor-critic algorithms in this setting of function approximation

References:

- [1] S.Bhatnagar, An actor-critic algorithm with function approximation for discounted cost constrained Markov decision processes, Systems and Control Letters, Vol. 59, pp.760-766, 2010
- [2] S.Bhatnagar and Lakshmanan K., An Online Actor–Critic Algorithm with Function Approximation for Constrained Markov Decision Processes, Submitted, 2011

Algorithms for Parameterized SDEs

- Consider a process $X(t) \in \mathcal{R}^d$, $t \geq 0$ whose sample paths are governed by the parameterized SDE

$$dX(t) = b(X(t), \theta(t))dt + \sigma(X(t), \theta(t))dW(t). \tag{1}$$

- Here $\theta(t)$, $t \geq 0$ is the associate parameter process and $W(\cdot)$ is a 1-dimensional Brownian motion. Further, $b : \mathcal{R}^d \times \mathcal{R} \to \mathcal{R}^d$ and $\sigma : \mathcal{R}^d \times \mathcal{R} \to \mathcal{R}^d$ are the drift and diffusion terms, respectively.
- We develop stochastic algorithms for optimal parameter tuning and control in this setting and study novel applications in slotted Aloha.

References:

- [1] Bhatnagar, S., Karmeshu and Mishra, V.K. (2009) "Optimal parameter trajectory estimation in parameterized SDEs: An algorithmic procedure", *ACM Transactions on Modeling and Computer Simulation*, 19(2): 8:1–8:27.
- [2] Karmeshu, Bhatnagar, S. and Mishra, V.K. (2011) "An optimized SDE model for slotted Aloha", *IEEE Transactions on Communications*, Vol. 59, No. 6, pp.1502-1508, 2011.

Discrete Parameter Stochastic Optimization

- We have developed efficient algorithms for problems of tuning in discrete parameter spaces.
- These algorithms are based on smoothed functional and simultaneous perturbation approaches and consistently outperform the current state-of-the-art OCBA algorithm.

References:

- [1] Bhatnagar, S., Mishra, V.K., Hemachandra, N. (2011) Stochastic algorithms for discrete parameter simulation optimization, IEEE Transactions on Automation Science and Engineering, Vol. 9, Issue 4, pp.780-793.