Substochastic Monte Carlo

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Pragmatics of SAT, 2016

http://brad-lackey.github.io/substochastic-sat/

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Substochastic Monte Carlo

What is it?

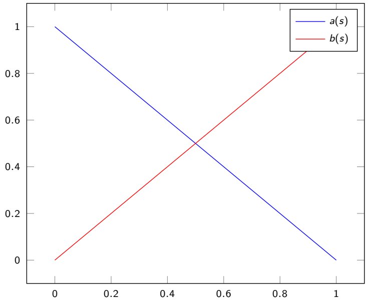
SSMC is an optimization algorithm intended to simulate the quantum adiabatic algorithm.

Substochastic Monte Carlo

Not that unfamiliar. Mix an appropriate amount of dynamics with a cost function with a time-dependent parameter s.

$$H(s) = a(s)L + b(s)W$$

$L =$ bit flips (random walk on hypercube)
$W =$ cost function (number of unsatisfied clauses)



Substochastic Monte Carlo

We look at the continuous time algorithm described by

$$\frac{d\vec{p}}{ds} = -TH(s)\vec{p}.$$

$H(s)$ describes a (substochasic) Markov process. Because the total number of walkers $\|p\|_1$ decreases in time, we let the walkers give birth to renormalize the distribution.
At a given time step s each walker

- flips a random bit,
- does nothing,
- gives birth,
- or dies

with probabilities given by the substochastic process at s.

Not really a heuristic

Why do we expect this to solve a SAT problem?

Not really a heuristic

Why do we expect this to solve a SAT problem?

1. An adiabatic theorem says that if we initially distribute our walkers according to a known distribution we can vary the process to always remain in the lowest energy configuration. (We choose this configuration to solve the optimization problem.)
2. Similar flavor to simulated annealing, but we have an easier time "tunneling"
3. Converges to "go-with-the-winners" in one limit (Aldous and Vazirani, FOCS, 1994)

Current Implementation

1. Run with a population of 16 walkers
2. Experimentally determined runtime T
3. Maximally allowed step size while preserving substochasticity

How is this different from existing solvers?

1. Not a partial solver. Each step evaluates the complete cost function.
2. Not presently using any specifics of Max-SAT and assuming that bit flips are the best dynamics.
3. Little preprocessing (naive biasing which may hurt us)
4. Fails without tautology removal (artifact of implementation)

Open questions and future work:

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Everything.

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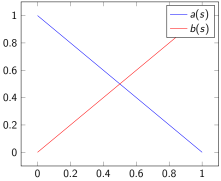
1. Better dynamics (other graphs) or varying graphs
2. Pre-processing
3. Dynamically updated annealing schedules
4. Learning processes



Questions?

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