Online Learning
- Learner gets the next example $x_t$, makes a prediction $p_t$, receives actual label $y_t$, suffers loss $\ell(p_t, y_t)$, updates itself
- Simple and fast predictions and updates
  $$p_t = w_t^T x_t$$
  $$w_{t+1} = w_t - \eta \nabla \ell(p_t, y_t)$$
- Online gradient descent asymptotically attains optimal regret
- Online learning scales well

Parallel Online Learning
- ... but it’s a sequential algorithm
- What if examples arrive very fast?
- What if we want to train on huge datasets?
- We investigate ways of distributing predictions, and updates while minimizing communication.

Delay
- Parallelizing online learning leads to delay problems.
- This is exacerbated in a setting with temporally correlated or adversarial examples.
- We investigate no delay and bounded delay schemes.

Each node has $f + 1$ weights where $f$ is the node’s fan-in. Bottom nodes use subsets of raw features. Others use predictions of their children.

Label travels together with prediction, available in each node

Local Updates
Each node in the tree:
- Computes its prediction $p_{ij}$ based on its weights and inputs
- Sends $\hat{y}_{ij}$ to its parent
- Updates its weights based on $\nabla \ell(p_{ij}, y)$
No delay
Limited representation power: between Naive Bayes and centralized linear model.

Parallel Online Learning
- Experiments with Global (and Local) Updates
- Some Experiments with Local Updates
- Improvements due to nonlinearity $\sigma$

Global Updates
- Unfortunately, local updates can also hurt performance.
- Improved representation power by global training.
- Slightly more communication, some delay.
- Delayed global training
  - Each node predicts but doesn’t immediately train on $y$.
  - Later it receives global prediction $y$ and trains as if it predicted that.
- Delayed backprop
  - The tree can be thought of a neural network
  - Lockstep backpropagation would be slow
  - Each node trains locally, sends prediction after training.
  - Later it receives global gradient from parent uses chain rule as in backprop.
- Delay fixed (helps stability, development and debugging)

Experiments with Global (and Local) Updates
- RCV1
- Webspam

Vowpal Wabbit
This (and more) is implemented in Vowpal Wabbit.
http://hunch.net/~vw
Fork it from http://github.com/JohnLangford/vowpal_wabbit

WWW: http://hunch.net/~vw