APPLIED MACHINE LEARNING AT FACEBOOK: A DATACENTER INFRASTRUCTURE PERSPECTIVE

Kim Hazelwood
Facebook AI Infrastructure
RE-EMERGENCE OF MACHINE LEARNING

Gradient-Based Learning Applied to Document Recognition, LeCun et al., 1998
WHY NOW?

Better Algorithms

More Compute

Bigger (and better) Data
MACHINE LEARNING EXECUTION FLOW

Data → Features → Training → Evaluation → Inference

Offline → Online
MACHINE LEARNING EXECUTION FLOW

Data -> Features -> Training -> Eval -> Model -> Inference -> Predictions
LET’S ANSWER SOME PRESSING QUESTIONS

• How does Facebook leverage machine learning?
• Does Facebook design hardware? For machine learning?
• Does Facebook design machine learning platforms and frameworks?
• Are these hardware and software solutions available to the community?
• What assumptions break when scaling to 2B people?
HOW DOES FACEBOOK USE MACHINE LEARNING?

- Search
- Translation
- Ads
- Face tagging
- News Feed
MAJOR SERVICES AND USE CASES

- News Feed
- Ads
- Search
- Sigma
- Facer
- Lumos
- Language Translation
- Speech Recognition

Classification Service → Content Understanding
WHAT ML MODELS DO WE LEVERAGE?

- Support Vector Machines: SVM
- Gradient-Boosted Decision Trees: GBDT
- Multi-Layer Perceptron: MLP
- Convolutional Neural Nets: CNN
- Recurrent Neural Nets: RNN

- Facer
- Sigma
- News Feed
- Ads
- Search
- Sigma
- Facer
- Lumos
- Language Translation
- Speech Rec
- Content Understanding
HOW OFTEN DO WE TRAIN MODELS?

Feed/Ads

minutes  hours  days  months

Facer
HOW LONG DOES TRAINING TAKE?

- **Facer**
  - seconds

- **Language Translation**
  - minutes
  - hours
  - days
HOW MUCH COMPUTE DOES INFERRENCE CONSUME?

News Feed: 100X
Sigma: 10x

AIDC
LET'S ANSWER SOME PRESSING QUESTIONS

• How does Facebook leverage machine learning?
• Does Facebook design hardware? For machine learning?
• Does Facebook design machine learning platforms and frameworks?
• Are these hardware and software solutions available to the community?
• What assumptions break when scaling to 2B people?
FACEBOOK AI ECOSYSTEM

**Frameworks:** Core ML Software
Caffe2 / PyTorch / etc

**Platforms:** Workflow Management, Deployment
FB Learner

Large-Scale Infrastructure
Servers, Storage, Network Strategy
THE INFRASTRUCTURE VIEW

Data → Offline Training → Online Inference

Storage Challenges! → Network Challenges! → Compute Challenges!
DOES FACEBOOK DESIGN HARDWARE?

- Yes! All designs released through the Open Compute Project since 2010
- Facebook Server Design Philosophy
  - Identify a small number of major services with unique resource requirements
  - Design servers for those major services
TWIN LAKES

For the web tier and other “stateless services”
Open Compute “Sleds” are 2U x 3 Across in an Open Compute Rack
TIOGA PASS

For compute or memory-intensive workloads:
BRYCE CANYON AND LIGHTNING

For storage-heavy workloads
In 2017, we transitioned from Big Sur to Big Basin GPU Servers for ML training.

**Big Sur**
Integrated Compute
8 Nvidia M40 GPUs

**Big Basin**
JBOG Design (CPU headnode)
8 Nvidia V100 GPUs per Big Basin
LET’S ANSWER SOME PRESSING QUESTIONS

• How does Facebook leverage machine learning?
• Does Facebook design hardware? For machine learning?
• Does Facebook design machine learning platforms and frameworks?
• Are these hardware and software solutions available to the community?
• What assumptions break when scaling to 2B people?
FACEBOOK AI FRAMEWORKS

**Caffe**
- Used for Production
- Stability
- Scale & Speed
- Data Integration
- Relatively Fixed

**PyTorch**
- Used for Research
- Flexible
- Fast Iteration
- Debuggable
- Less Robust
DEEP LEARNING FRAMEWORKS

Framework backends

Vendor and numeric libraries
OPEN NEURAL NETWORK EXCHANGE

Shared model and operator representation

From $O(n^2)$ to $O(n)$ pairs

Framework backends

Vendor and numeric libraries
Facebook AI Ecosystem

**Frameworks:** Core ML Software
Caffe2 / PyTorch / etc

**Platforms:** Workflow Management, Deployment
FB Learner

Large-Scale Infrastructure
Servers, Storage, Network Strategy
FB LEARNER PLATFORM

- AI Workflow
- Model Management and Deployment
TYING IT ALL TOGETHER

Data

Features

Training

Evaluation

Inference

FB Learner
Feature Store

FB Learner
Flow

FB Learner
Predictor

Bryce Canyon

Big Basin

Tioga Pass

Twin Lakes
What changes when you scale to over 2 BILLION PEOPLE
SCALING CHALLENGES / OPPORTUNITIES

Lots of Data

Lots of Compute
SCALING CHALLENGES / OPPORTUNITIES: DATA

Lots of Data

Data quality (and potentially quantity) correlates well with user experience

Network design matters
Geographic locations matter
Database configs matter
SCALING CHALLENGES / OPPORTUNITIES: COMPUTE

Lots of Compute

Can leverage idle resources on nights and weekends for “free”

Must consider geographic resource distribution
SCALING OPPORTUNITY: FREE COMPUTE!
SCALING CHALLENGES: DISASTER RECOVERY

• Seamlessly handle the loss of an entire datacenter
• Geographic compute diversity becomes critical
• Delaying even the offline training portion of machine learning workloads has a measurable impact
**KEY TAKEAWAYS**

- Facebook AI
- Lots of Data
- Wide variety of models
- Full stack challenges
- Global scale