Welcome to the Jet Age
How AI and DL Makes Online Shopping Smarter at Walmart
Today

1. GPU GA for Smart Merchant Selection
2. Deep Reinforcement Learning for Packing
Introduction

US eCommerce site dedicated to savings

Revolutionary pricing engine

Top technology and fulfillment platform

Acquired by Walmart in mid 2016
Introduction

Machine learning and Cognitive computing

Numerical HPC algorithm design and implementation

Specialized in GPU computing and parallel algorithms

Creator of Alea GPU
Smart Merchant Selection
Jet Pricing Engine

Users shop for products

Platform decides about most optimal fulfillment during shopping and at checkout

Savings come from

• Cheapest net item prices
• Pack items together for fewer boxes to ship
• Conditions, merchant commission, basket rules
• More efficient fulfillment
Savings Potential

Larger Carts – More Savings

Profit Potential

Larger carts – more savings
Full Search
Embarrassingly Parallel

1. Large number of ways to fulfill a shopping cart

2. Cart pricing can be executed independently

Ideal problem to solve in parallel with GPUs
Full Search
Exponential Complexity

Complexity = 

Number of combinations = 

$\text{num offers for item 1} \times \ldots \times \text{num offers for item } k$
Full Search on GPU

Full Search Speedup of Small Carts

- 300x speedup
- 50x speedup

Number of Combinations vs. Speedup
Example

Somebody wanted to build a computer
Exponential Complexity

Number of combinations =

Offers for item 1 * Offers for item 2 * . . . . * Offers for item 10

= 32 * 17 * 19 * 16 * 29 * 9 * 25 * 10 * 16 * 17 * 24

= 70,442,237,952,000 combinations

= $10^{13.85}$ combinations
Performance Gap

Full Search Timings

13.85 = \log_{10} 70'442'237'952'000

Real time gap
Genetic Algorithm

Apply Genetic Algorithms to solve the problem

- Standard GA does not work
  - Search space is astronomically large
  - Need a reliable high quality approx. solution
  - Calculations in near real-time
- Rely on AI & ML to choose GA configuration
- Generation iteration is serial, extending the population size dramatically allows to reduce iterations
Genetic Algorithm
Schematic Description

- Generate initial population
- Evaluate fitness
- Evaluate stopping criterion
- Elite selection
- Parents selection
- Crossover and mutation
- New population

AI & ML
Convergence
Embedding with TSNE

Initial population

Best part from full search
Special greedy «boundary» points

Score rapidly improves
Catches best points found by full search

1. generation

4. generation
Wal-Mart Will Bring Jet's Smart-Cart Buying System to Its Site

By Matthew Boyle
October 10, 2017 4:35 PM CEST

Wal-Mart Expects a 40% Surge in Online Sales
Deep Reinforcement Learning for Packing
Optimal Packing

Non-standard Multi-container Loading Problem

- 30 – 40 different container types
- Choose the best containers to pack in as few containers as possible
- Respect many constraints
- Add optional coolant for fresh
- Minimize waste volume
Learning Approach

GA is powerful but

• Slow (complex constraints)
• Hard to move to GPU (constraints, placement heuristics)

Deep Reinforcement Learning

• More natural (cost resp. reward based)
• More flexible
• Bootstrapping with solutions from GA
• Requires retraining when container types change
Deep Reinforcement Learning

Learning a behavioral strategy which maximizes long term sum of rewards by a direct interaction with an unknown and uncertain environment.

While not terminal do:
- Agent perceives state \( s_t \)
- Agent performs action \( a_t \)
- Agent receives reward \( r_t \)
- Environment evolves to state \( s_{t+1} \)
Placements in Containers

Free subspaces keep track of potential placements
Reinforcement Learning Setup

States
• Opened containers
• Free subspaces of each opened container
• Remaining boxes to pack

Immediate reward
• Number of containers used so far
• Waste volume
• Constraints violations

Final reward
• Total shipping costs

Action
• Option to open new container
• Choose an orientation of the box
• Choose a free subspace in a container to place the box
Reinforcement Learning Performance

Compare to baseline random search
Questions?