ACCELERATING AI IN COSMETICS
THE CASE OF L’ORÉAL HAIRCOACH
AN OVERVIEW OF GPU APPLICATIONS AT L’ORÉAL

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1/ L’Oréal and AI
   >L’Oréal overview
   >AI at L’Oréal

2/ L’Oréal Hair Coach
   >Project overview
   >Data analysis

3/ Comparative performance of GPU and CPU
   >Benchmarking procedure
   >Results
   >Discussion
L’ORÉAL AND AI
ABOUT L’ORÉAL

WORLDWIDE LEADER IN BEAUTY

1st beauty company

22.5 billion € sales in 2014

12.5% market share

130 countries

78,610 employees

17.3% operating margin
ABOUT L’ORÉAL

A LARGE VARIETY OF PRODUCTS AND MARKETS
Key figures

5000 employees
Around 600 patents per year
Over 100 scientific partnerships worldwide
Over 800 M€ invested per year

Science & Technology

Chemistry (organic, pigments)
Optics (colour, models of skin and hair)
Mechanics (dispensing, robotics)
DATA SCIENCE AND AI AT L’ORÉAL
UNDERLYING TRENDS

Databases

- Labelled, qualified data for algorithms
- Importance of recommendation systems
- L’Oréal knowledge and historical data about human skin and hair.

Devices

- Billions of cheap connected ubiquitous devices
- Sophisticated tools for high quality data in the lab

Modeling & Rendering

- Growing applications of Augmented and Virtual Reality in cosmetics
- Computer Graphics for virtual and fast prototyping, evaluation of our products.
DIVERSITY OF APPLICATIONS

**Research**

- Chemical formulas
- Image/videos of face/hair
- Hair sound
- Patents

**Operations**

- 7 billions units produced per year
- Dozens of plants and distributions centers
- 1000s of raw materials & suppliers

**Business**

- 1+ billion consumers
- 100 000s final PoS
- Millions of online shoppers
- Dozens of brands in 100+ countries

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**Data**

- Prediction of formula characteristics (color, toxicity…)
- Design of Experiments
- Mechanical and optical models
- Document search and indexing

**Models**

- Operations Research
- Robotics & IoT
- Time series analysis
- Network/graph analysis

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L’ORÉAL

Research & Innovation

NVIDIA GTC Europe Conference – Munich – 10/10/2017
PROJECT OVERVIEW

BRUSH CHARACTERISTICS

Microphone
Listens to the sound of your hair and quantifies metrics

Load cells
Measures the force applied between the handle and the head brush

Accelerometer/Gyroscope
Counts and determines gentle/aggressive gesture

Conducted pin
Detects wet hair

Haptic feedback
Provides user feedback by vibrating

Wi-Fi & Bluetooth
Connects to the cloud and the user app
DATA ANALYSIS
OVERVIEW

Raw signals
Challenging real-life acquisition on head
- Messy raw signals
- Sound as potentially most informative

Signal processing
Making signal ready for analysis
- Cleaning raw signals
- Detection of brushing pattern
- Combining and weighting signals

Machine Learning
Obtaining hair characteristics
- Machine Learning and Deep Learning models
- “Correlation” between extracted features and hair characteristics

Filtering
Denoising
Acoustic analysis
Spectral methods
Scaling
Centering
Auto/cross-correlation analysis

Feature engineering
Feature extraction
Trend analysis
Envelope detection
Adaptive thresholding
DATA ANALYSIS
LSTM MODELS

Input data
Accelerometer and gyroscope data

Sample structure
Patches of 1 second (100 data points)

Supervised learning
Real movement labelled by technicians

Source: Christopher Olah
COMPARATIVE PERFORMANCE OF GPU AND CPU

L'ORÉAL
Research & Innovation

NVIDIA GTC Europe Conference – Munich – 10/10/2017
Comparison on similar dataset
- 889 samples of 100x6 dimensions
- Same randomized folds in the simulation and input files

Simple benchmarking metrics (with some personal interpretation)

Non compiled code (Windows) and no linear algebra libraries optimized for Intel

Cards sharing same hardware (memory, motherboard)

No other computing task done during the benchmark
## Benchmarking Procedure

### Comparison Metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>Running time (training and inference phases)</td>
<td>Seconds</td>
</tr>
<tr>
<td>Time efficiency (training phase)</td>
<td>FLOP per second (of training)</td>
</tr>
<tr>
<td>Running cost (training phase)</td>
<td>€ per second</td>
</tr>
<tr>
<td>Running power (training phase)</td>
<td>W per second</td>
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<tr>
<td></td>
<td>MHz per second</td>
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<tr>
<td></td>
<td>Transistor per second</td>
</tr>
<tr>
<td>Characteristic</td>
<td>GPU</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Model</td>
<td>NVIDIA K4200</td>
</tr>
<tr>
<td>Release date</td>
<td>Q3 2014</td>
</tr>
<tr>
<td>Price (2017€)</td>
<td>500</td>
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<tr>
<td>Lithography (nm)</td>
<td>28</td>
</tr>
<tr>
<td>Computation (GFLOPS)</td>
<td>90 (double precision), 2100 (SP)</td>
</tr>
<tr>
<td>Power (W)</td>
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</tr>
<tr>
<td>Frequency (MHz)</td>
<td>771</td>
</tr>
<tr>
<td>Transistors</td>
<td>3540</td>
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<tr>
<td>Metric</td>
<td>Unit</td>
</tr>
<tr>
<td>----------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Training time</td>
<td>s</td>
</tr>
<tr>
<td>Inference time (test set)</td>
<td>ms</td>
</tr>
<tr>
<td>Time efficiency</td>
<td>GFLOP.s(^{-1})</td>
</tr>
<tr>
<td>Time efficiency</td>
<td>MHz.s(^{-1})</td>
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<tr>
<td>Running cost (acquisition)</td>
<td>€.s(^{-1})</td>
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<tr>
<td>Running cost</td>
<td>Trans. s(^{-1})</td>
</tr>
<tr>
<td>Running power</td>
<td>W.s(^{-1})</td>
</tr>
</tbody>
</table>
Time-related performance

Training time

GPU (s)

CPU (s)
Influence of computational task

(DL) model hyperparameters (epochs, batch size)
Performance gap between training and inference

Impact of the hardware

Relative influence of compute and memory access
GPU more efficient for DL

In absolute terms, 5 (resp. 2.5) times faster for training (resp. inference)
Lower relative acquisition cost but higher relative running cost (energy consumption)
Improvement through frequency?

Next steps

Compare other ML/DL models and computational tasks (VR...)
Define better metrics for hardware comparisons
- Combining more than 2 criteria
- System-based
THANK YOU!

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