L'ORÉAL

Research & Innovation

ACCELERATING AI IN COSMETICS
THE CASE OF L'ORÉAL HAIRCOACH

AN OVERVIEW OF GPU APPLICATIONS AT L'ORÉAL

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

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L'ORÉAL AND AI

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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

A LARGE VARIETY OF PRODUCTS AND MARKETS

ACCROSS ALL DISTRIBUTION CHANNELS

HAIR SALONS

MASS MARKET

DEPARTMENT STORES PERFUMERIES

PHARMACIES DRUGSTORES MEDISPAS

BRANDED RETAIL

TRAVEL RETAIL

E COMMERCE

HAIRCARE

HAIR COLOR

SKINCARE

FRAGRANCE

MAKE-UP

ACCROSS ALL BEAUTY CATEGORIES

RESEARCH AT L'ORÉAL
OVERVIEW

Key figures

5000 employees

Around 600 patents per year

Over 100 scientific partnerships worlwide

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.

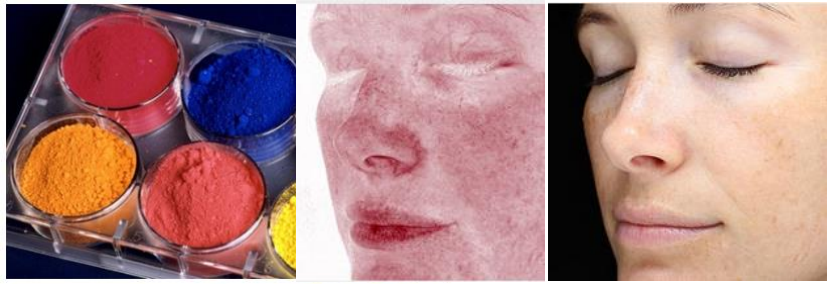
Devices

- 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.

DATA SCIENCE AND AI AT L'ORÉAL
DIVERSITY OF APPLICATIONS

	Research	Operations	Business
			
Data	• Chemical formulas • Image/videos of face/hair • Hair sound • Patents	• 7 billions units produced per year • Dozens of plants and distributions centers • 1000s of raw materials & suppliers	• 1+ billion consumers • 100 000s final PoS • Millions of online shoppers • Dozens of brands in 100+ countries
Models	• Prediction of formula characteristics (color, toxicity…) • Design of Experiments • Mechanical and optical models • Document search and indexing	• Operations Research • Robotics & IoT • Time series analysis • Network/graph analysis	• Precision advertising • Social Network Analysis • VR/AR/MR • A/B testing

L'ORÉAL HAIR COACH

L'ORÉAL
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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

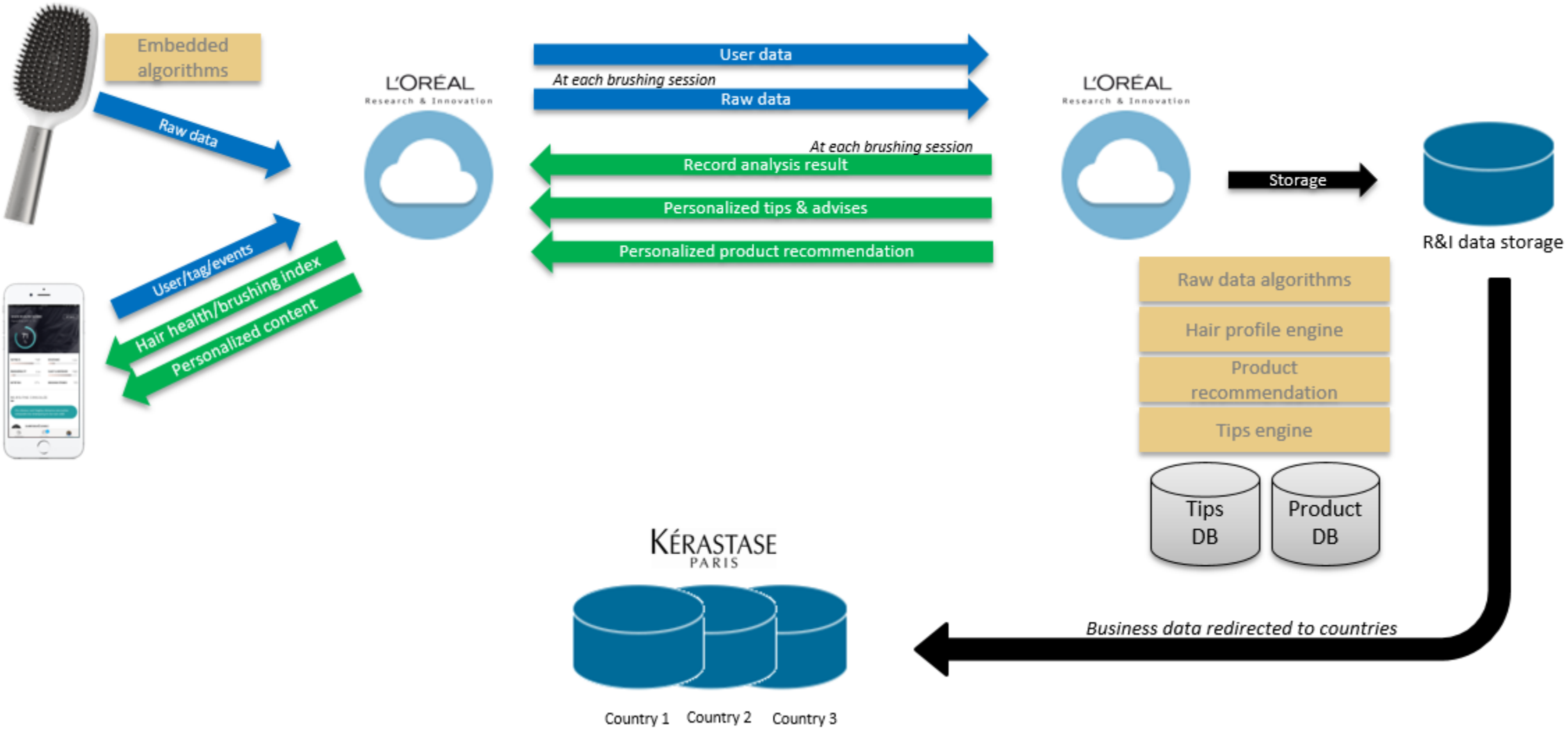
Accelerometer/Gyroscope
Counts and determines gentle/aggressive gesture

Conducted pin
Detects wet hair

Haptic feedback
Provides user feedback by vibrating

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

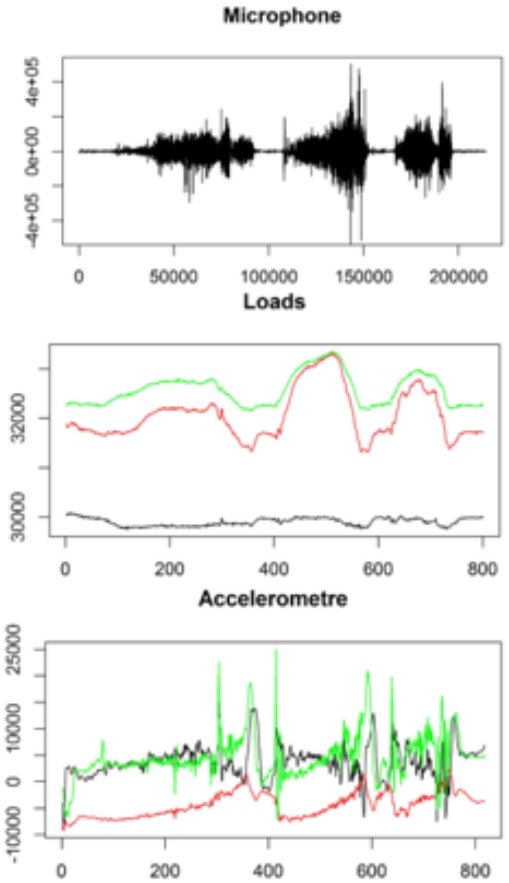
PROJECT OVERVIEW
DATA PLUMBING



DATA ANALYSIS
OVERVIEW

Raw signals
Challenging real-life acquisition on head

- Messy raw signals
- Sound as potentially most informative



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Filtering

Denoising

Acoustic analysis

Spectral methods

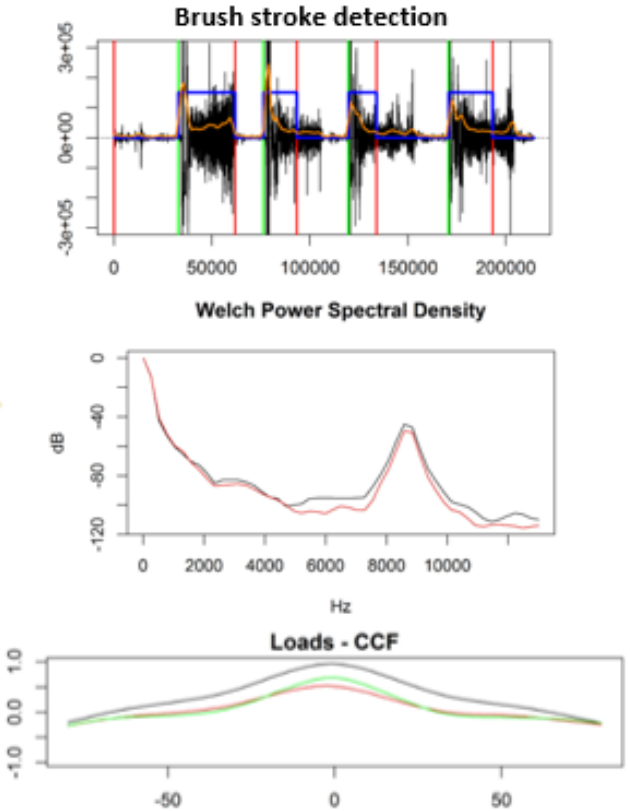
Scaling

Centering

Auto/cross-correlation analysis

Signal processing
Making signal ready for analysis

- Cleaning raw signals
- Detection of brushing pattern
- Combining and weighting signals



Feature engineering

Feature extraction

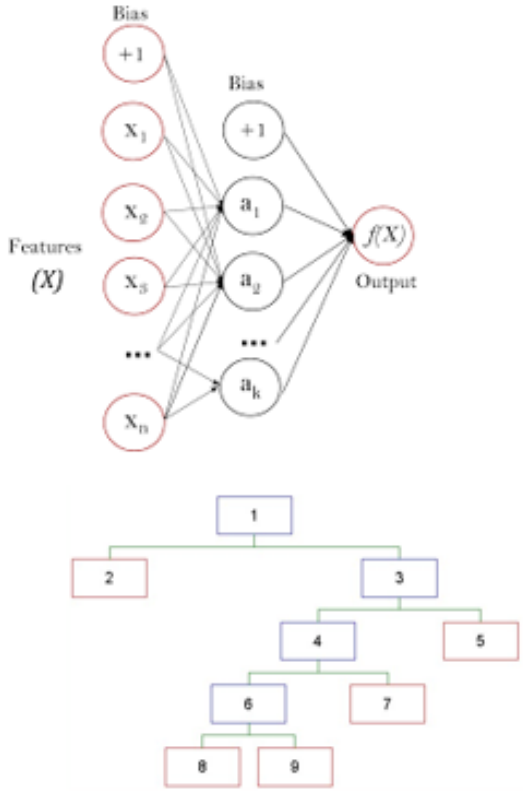
Trend analysis

Envelope detection

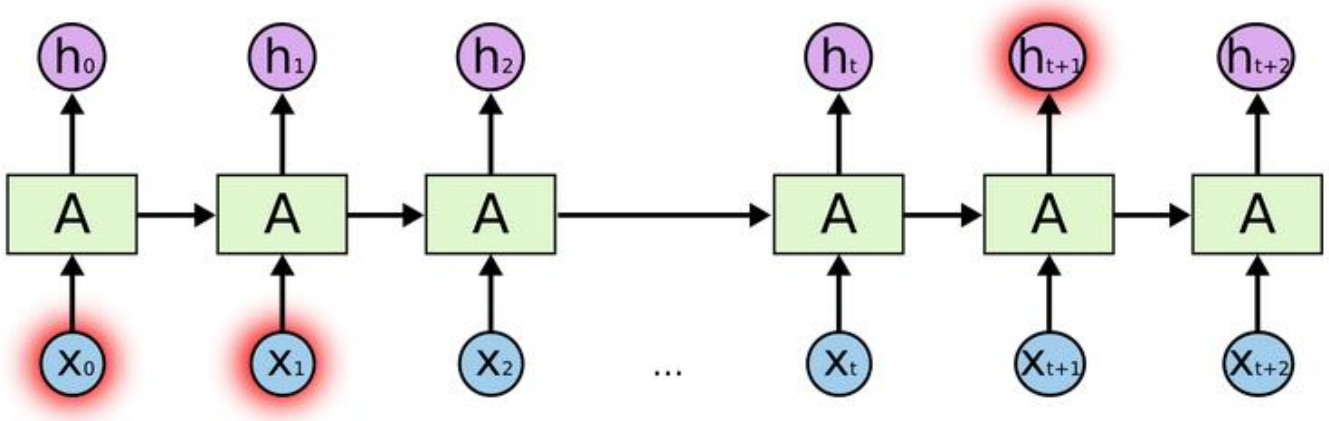
Adaptive thresholding

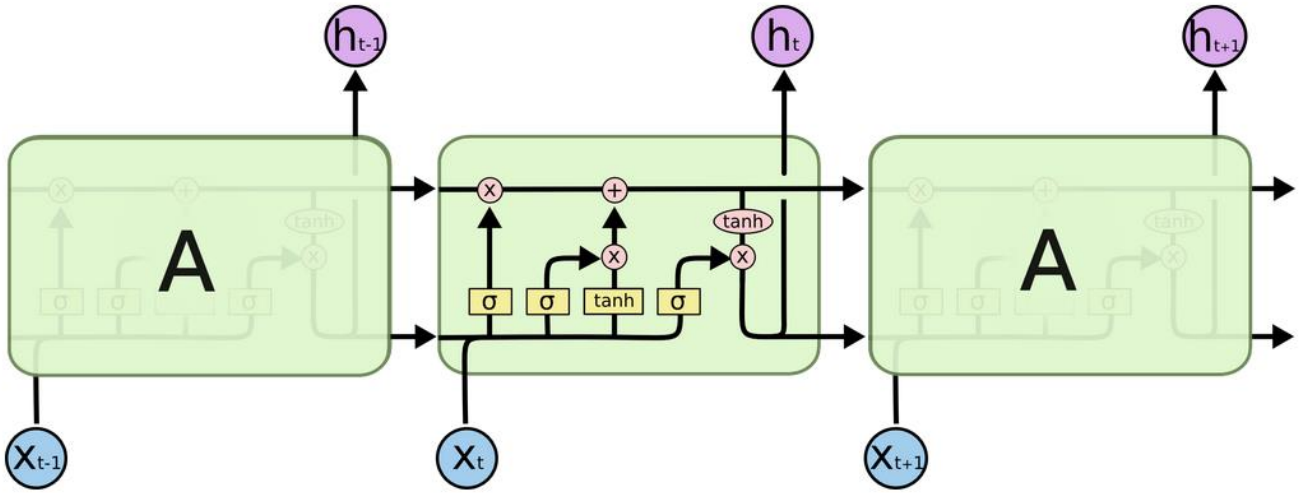
Machine Learning
Obtaining hair characteristics

- Machine Learning and Deep Learning models
- "Correlation" between extracted features and hair characteristics



DATA ANALYSIS
LSTM MODELS

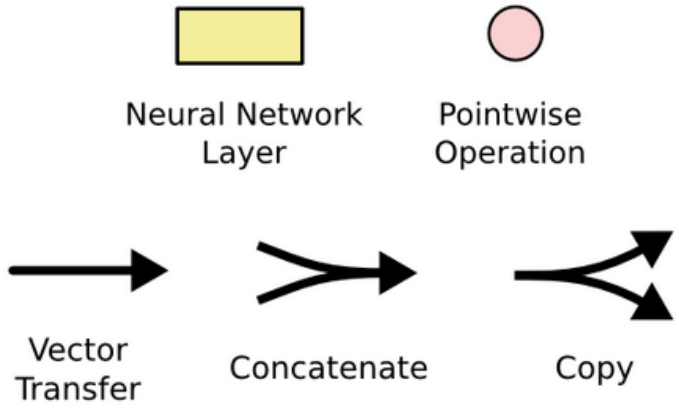




Input data
Accelerometer and gyroscope data

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

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BENCHMARKING PROCEDURE
METHOD

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 librairies optimized for Intel

Cards sharing same hardware (memory, motherboard)

No other computing task done during the benchmark

BENCHMARKING PROCEDURE
COMPARISON METRICS

Metric	Unit
Running time (training and inference phases)	Seconds
Time efficiency (training phase)	FLOP per second (of training) MHz per second
Running cost (training phase)	€ per second Transistor per second
Running power (training phase)	W per second

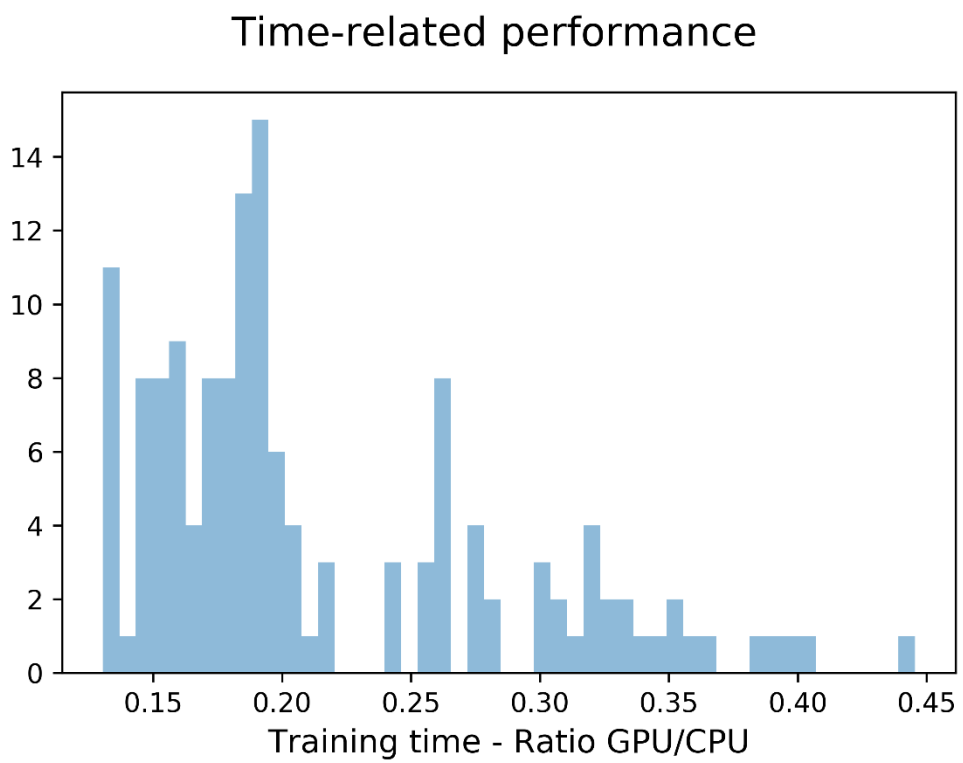
BENCHMARKING PROCEDURE
HARDWARE

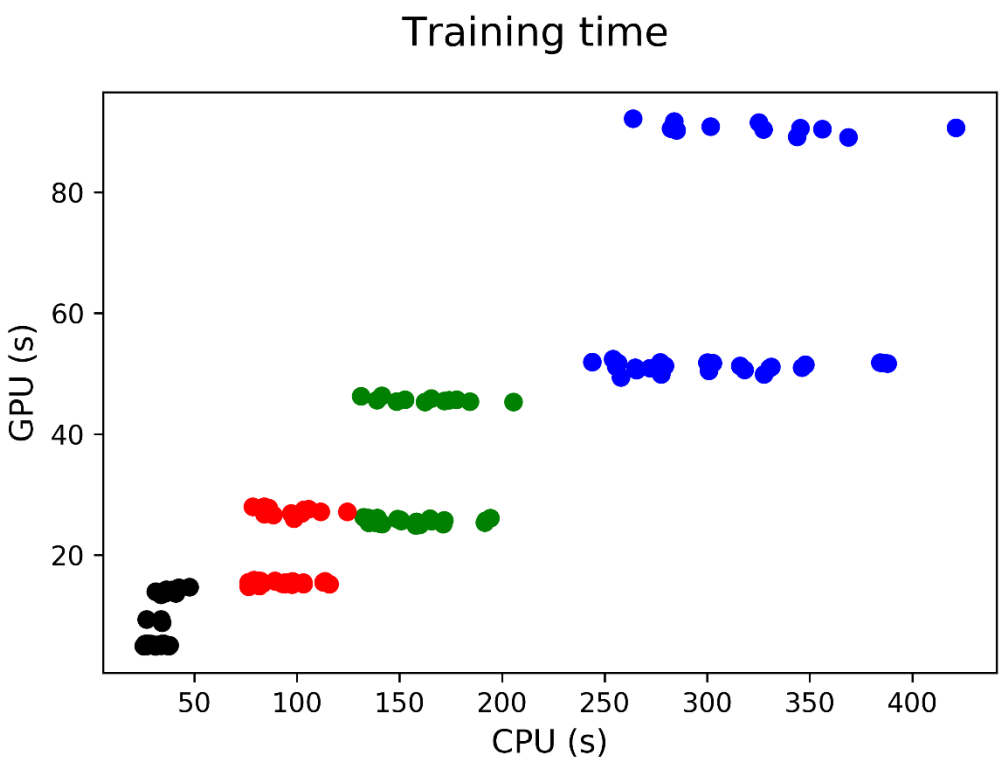
Characteristic	GPU	CPU	Ratio GPU/CPU
Model	NVIDIA K4200	Intel Core i7-4500U1	
Release date	Q3 2014	Q3 2013	
Price (2017€)	500	400	**1.25**
Lithography (nm)	28	22	**1.3**
Computation (GFLOPS)	90 (double precision), 2100 (SP)	11.4	**8**
Power (W)	108	15	**7**
Frequency (MHz)	771	1800	**0.4** (less but improvable)
Transistors	3540	1300	**2.7** (more but less improvable)

RESULTS SUMMARY

Metric	Unit	GPU	CPU	Ratio GPU/CPU
Training time	s	30.9 (23.9) [4.8-92.2]	148.2 (107.2) [25.3-421.3]	**0.2 (5x faster)**
Inference time (test set)	ms	109.4 (27.5) [78-20.3]	278.8 (57.3) [186.1-380.3]	**0.4 (2.5x faster)**
Time efficiency	$GFLOP.s^{-1}$	2.91	0.077	**37.9**
Time efficiency	$MHz.s^{-1}$	24.9	12.1	**2**
Running cost (acquisition)	$€.s^{-1}$	16.2	2.7	**6 (17% of CPU)**
Running cost	Trans. s^{-1}	114.6	8.8	**13**
Running power	$W.s^{-1}$	3.5	0.1	**35 (1.4x of CPU)**

RESULTS DETAILS





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

DISCUSSION
CONCLUSION

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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