Big Data and Internet Search
James Larus
Professor and Dean IC
December 13, 2016

How Does a Search Engine Work?

[Image of Google search with input 'new.york.pizza']
Easy Part

Index every non-trivial word on every page

Just Takes Computers

1632 for ~50 billion web pages
(x6 for availability and throughput)
Hard Part

Currently Machine-Learned Algorithm
Clickstream is BIG Data

Search Engine Relevance (NDCG)
Machine Learning
EPFL Master Program in Data Science

Martin Jaggi
EPFL

13th Dec 2016
What is Machine Learning?
What is Machine Learning?

software that can

learn from data
Classification

$\mathbf{x}_i \in \mathbb{R}^d$

Training data
Classification

Training data

$x_i \in \mathbb{R}^d$
Classification

$\mathbf{x}_i \in \mathbb{R}^d$
Classification

$x_i \in \mathbb{R}^d$
Classification

Training data

$x_i \in \mathbb{R}^d$
towards…
understanding intelligence
?

if-then-else
≠
intelligence
towards...
understanding intelligence?

Machine Learning vs Neuroscience
why ML?

Applications
Industry Applications
Applications in Other Sciences

- increasingly data driven
  - science of $X \rightarrow$ digital science of $X$
Image Data

- Astronomy
- Face recognition
- 2D + 3D medical imaging
- OCR
- self-driving cars
Image Data

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how-old.net
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<th>Label</th>
<th>Text</th>
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<td>But i wanna wear my Concorde tomorrow though but i don't feel like it</td>
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<tr>
<td>positive</td>
<td>Gonna watch Grey's Anatomy all day today and tomorrow(:</td>
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<tr>
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<td>The Rick Santorum signing that was scheduled for tomorrow at the Books A Million</td>
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Medical: Genetic Data
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Audio Data

- Hearing aids
- Voice Recognition
- Automatic Translation
Numerical / Sensor Data

- Cern
- SKA, Telescopes
- Fitness Trackers
- Weather Forecast
- Robotics
- Kinect
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Games & Simulations

- Immediate Feedback
Games & Simulations

- Immediate Feedback
- Chess, Go
Games & Simulations

- Immediate Feedback
- Chess, Go
Games & Simulations

- Immediate Feedback
- Chess, Go
- Physical World
Internet Data

Prediction Markets

$\approx U V^T$
ML Applications
by Master Students
Generating Maps from Satellite Images
Medical Applications in Intensive Care

Forecasting of intracranial hypertension

43 GB of raw CSV text data
67 days of ICP signal
sampling rate 125 Hz

MSc Thesis Projects
Matthias Hüser & Adrian Kündig
Medical Applications in Intensive Care

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MSc Thesis Projects
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### Text Understanding

#### sentiment of tweets

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**SemEval 2016:**
winner out of 34
teams, >20 countries

MSc Thesis Projects
Jan Deriu & Maurice Granzebach
Audio: Bird Songs & Ecology

another kind of tweets

winner of
BirdCLEF 2016

MSC Thesis Project
Elias Sprengel

Illustration by Freepik
thanks
Data Science job market

Data Scientist: The Sexiest Job of the 21st Century

by Thomas H. Davenport and D.J. Patil

To capture the full economic potential of big data, companies and policy makers will have to address the talent gap. New research by the McKinsey Global Institute (MGI) projects that by 2018, the United States alone may face a 40 to 90 percent gap between supply and the requisite demand of deep analytic talent, i.e., people with advanced training in statistics or machine learning.

Here is a look at the current state of the U.S. talent base—this interactive examines nine occupational categories populated by people who can execute big data analytics and the industries where those specialists can be found.
Yes, Data Science programs are everywhere, but...

Complete academic programs:
- They are rare.
- Many existing programs are “vocational training”.

Focus on Foundations:
- Statistics
- Information Theory, Signal Processing

Focus on Algorithms:
- Machine Learning

Focus on Systems Design:
- Database systems, Big Data
- Information Security and Privacy

Focus on Practical Real-World Data
Structure of Program (120 credits)

- MS Thesis Project (30)
- Semester Projects (18)
- Options (42)
- Core (30)

Core (30 credits: 5 out of 8 classes)

**Existing Classes:**
- Advanced Algorithms (CS-450)
- Machine Learning (CS-433)

**Evolutions of Existing Classes:**
- Systems for Data Science (DS-?)
- Applied Data Analysis (CS-401, new in Fall 2016)

**New Classes lined up (more or less):**
- Statistics for Data Science (MATH-?)
- Information security and privacy (COM-402)

**New Classes being designed:**
- Information Theory and Signal Processing
- Optimization for Machine Learning and Data Science
Optional Courses (42 credits)

- Current plan is based on *existing* classes mostly.
- Classes from
  - Computer Science
  - Communication Systems
  - Mathematics
  - Statistics
  - Electrical Engineering
- “Data Visualization”
- Optional Project (8 credits)

- Future optional courses to be developed specifically for Data Science.
  - IC is hiring in Machine Learning and Data Science

Semester Projects (18 credits)

- Semester projects can be carried out in IC (just like our MS students in Computer Science and SysCom)
- Or in other data science related labs on campus (SV and many more).

- SHS Project (6 credits, as usual)
Masters Project (30 credits)

- MS Projects will be carried out in industry or at EPFL (as all MS projects in IC).
- **Fact:** More than half of the current MS projects in IC (Computer Science and Communication Systems) *already* involve Data Science anyway.

Who can access the MS in Data Science?

- It is a regular MS in IC.
- All IC Bachelor students can enter just like they can enter the MS in Computer Science and the MS in Communication Systems.
- It is open to all EPFL BS students on dossier.
- Generically, this will require additional prerequisite course work (as any switch in study major at EPFL).
- Some of this could be taken already in the 3rd year BS as optional credit.
Key Prerequisites (Draft)

• Already mandatory for both CS and SysCom:
  • Algorithms (CS 250)
  • Theory of Computation (CS 251)

• Additionally recommended for SysCom (mandatory for CS):
  • Introduction to Database Systems (CS 322)
  • Parallelism and Concurrency (CS 206)
  • Functional Programming (CS-210)

• Additionally recommended for CS (mandatory for SysCom):
  • Circuits & Systems II (EE-205)
  • Stochastic Models (COM 300)
  • Signal Processing (COM 303)

Footnotes

• “Specializations”:
  Initially, this MS will not offer specializations.
  • It is sufficiently specialized.
• But specializations are definitely an option for the future.

• Digital Humanities:
  • No overlap in key Job Markets.
  • Small overlap in intellectual contents:
    • Two core courses (“Applied Data Analysis” and “Pattern Classification and Machine Learning”)

### Stage d'ingénieur :

Voir les modalités dans le règlement d'application

### Mineurs :

Le cursus peut être complété par un des mineurs figurant dans l'offre de l'EPFL (renseignements à la page sac.epfl.ch/mineurs), à l'exclusion des mineurs "Computer Engineering", "Informatique", "Information security" et "Systèmes de communication" qui ne peuvent pas être choisis.

Parmi les mineurs offerts par l'EPFL, la section recommande à ses étudiants les mineurs suivants :
- Biocomputing (SIN)
- Computational Science and Engineering (SMA)
- Management de la technologie et entrepreneuriat (SMTE)
- Technologies biomédicales (SMT)
- Technologies spatiales (SEL)

Le choix des cours de tous les mineurs se fait sur conseil de la section de l'étudiant et du responsable du mineur.

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#### Cycle Master

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<th>Enseignants</th>
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#### Groupe 2 : Options

Le somme des crédits de groupes 1 et 2 doit être de 72 crédits au minimum.

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<td>Enseignants</td>
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|      | **Bien "Projets et MCV" :** |        |             |          |           |         |         |      |
| DG-416 | Projet de recherche en data science | Diversifiés | Enseignants | SC | 4 3 | 12 | sem.A ou P |
| BIOM-750 | PhD introduction to research | Diversifiés | Enseignants | SB | 2 1 | 3 | sem.A |
| BIOM-750 | PhD project | Diversifiés | Enseignants | SB | 3 | 3 | sem.P |

**Total des crédits du cycle master** | 90 |
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