Decision-theoretic Machine Learning

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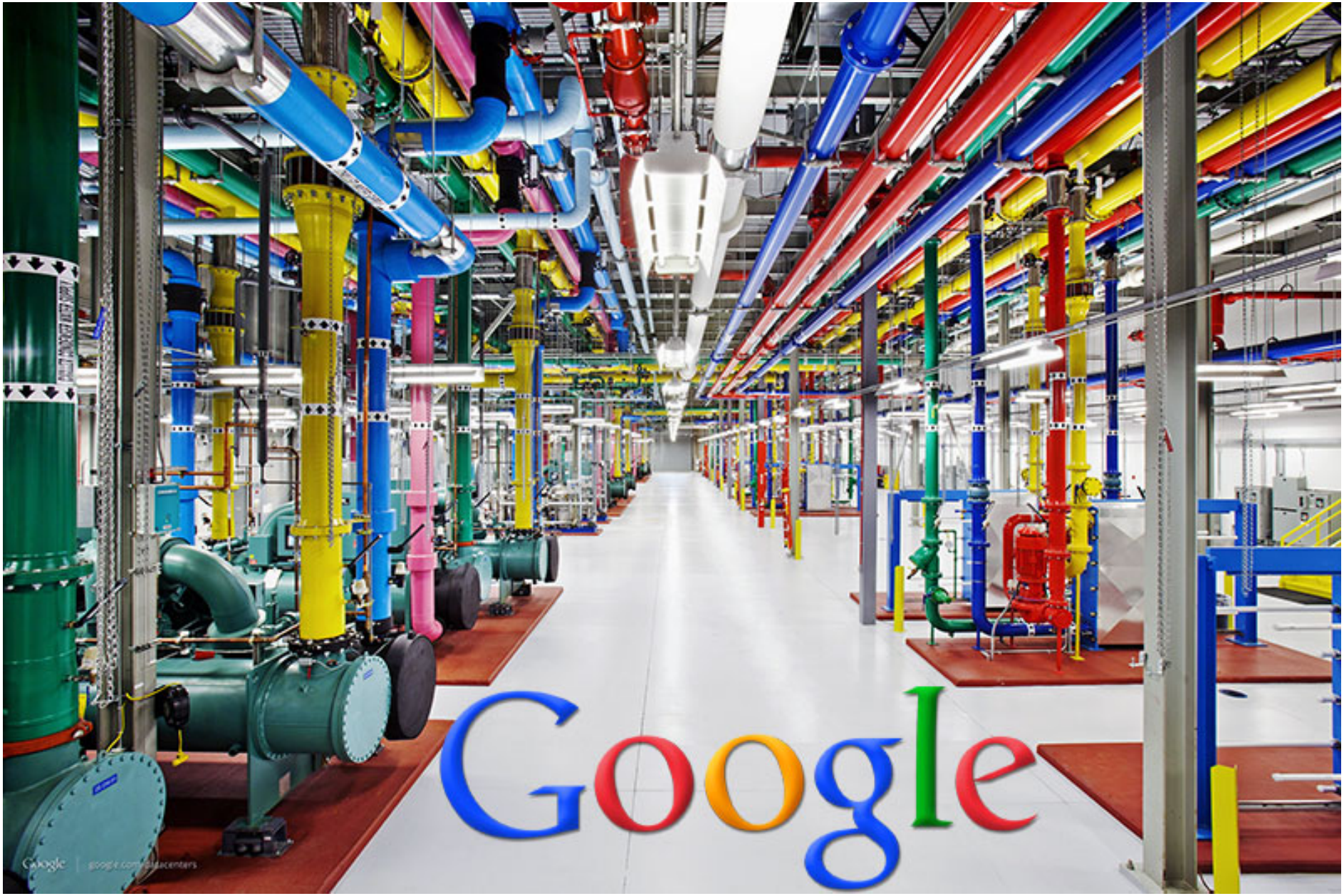
- **Wojciech Kotłowski**:
  - Main interest: **machine learning** (online-learning, matrix learning, preference learning, learning theory)
  - Past interest: multi-criteria decision aiding, decision rule models
  - Education: MSc (2004 in Computer Science, 2006 in Physics), PhD (2009).
  - Postdoc: Centrum Wiskunde & Informatica (2009-2012).

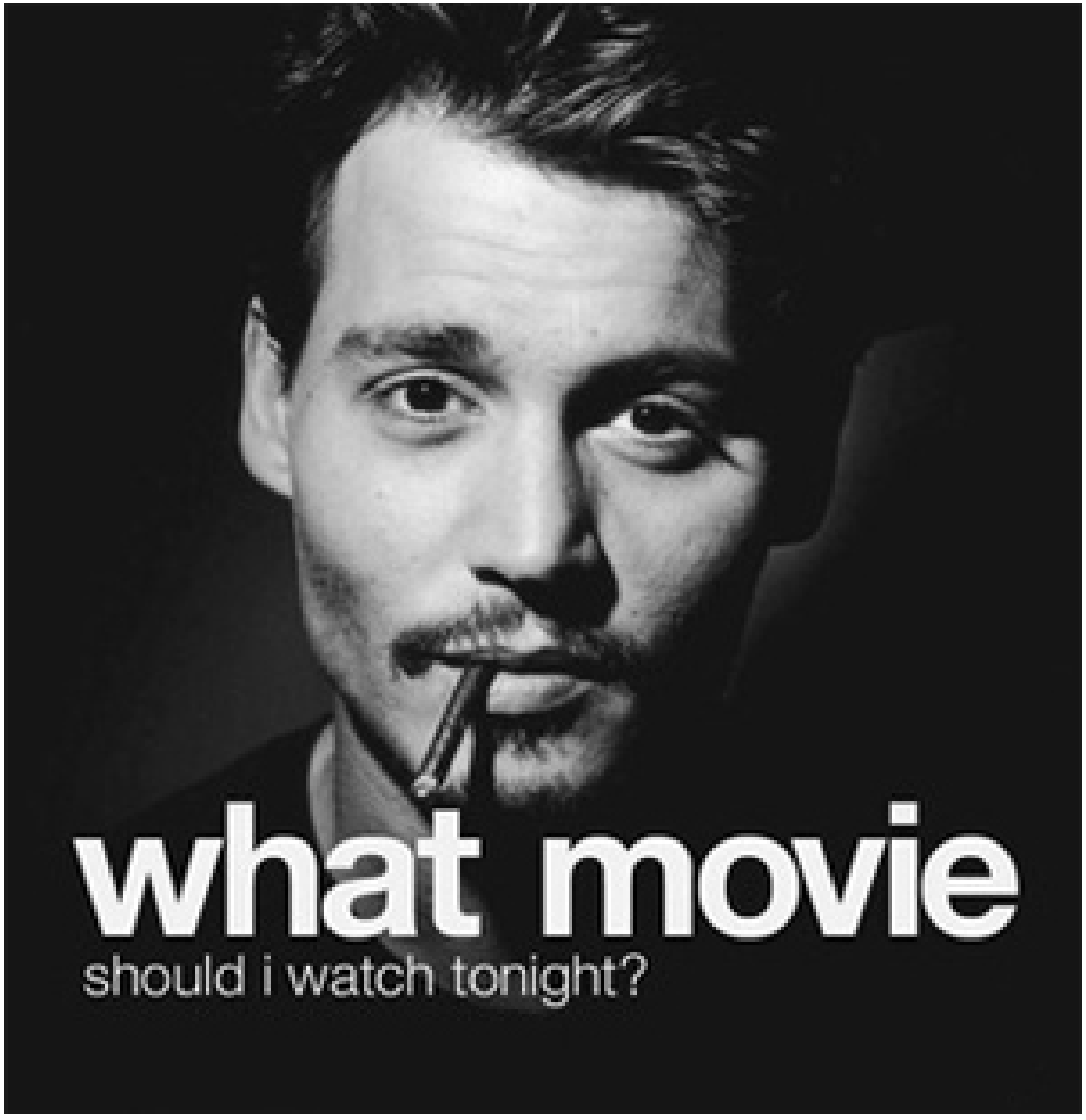
- **Krzysztof Dembczyński**:
  - Main interest: **machine learning** (multi-label classification, structured output prediction, preference learning, learning theory)
  - Past interest: multi-criteria decision aiding, decision rule models
  - Education: MSc (2001), PhD (2009).
  - Postdoc: Marburg University (2009-2011).

- We both work in Laboratory of **Intelligent Decision Support Systems**, headed by **Roman Słowiński**, at **Poznań University of Technology**.
- We try to do our best in machine learning: conference articles at **ICML**, **NIPS**, **COLT**, journal articles in **JMLR**, **MLJ**, **DMKD**, **TDE**, serving as PC members of major AI conferences (**ICML**, **NIPS**, **COLT**, **IJCAI**, **AAAI**, **KDD**).

We live in the era of Big Data and Machine Learning.



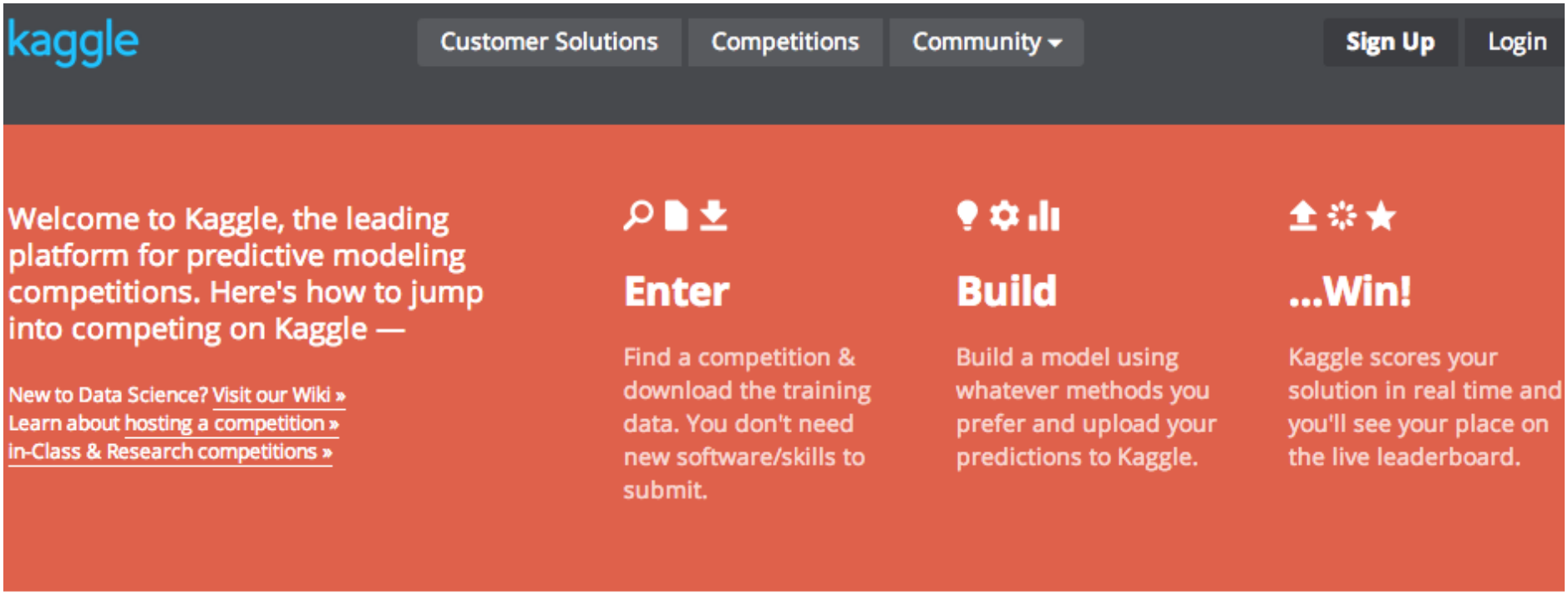
Search engines: website ranking and personalization

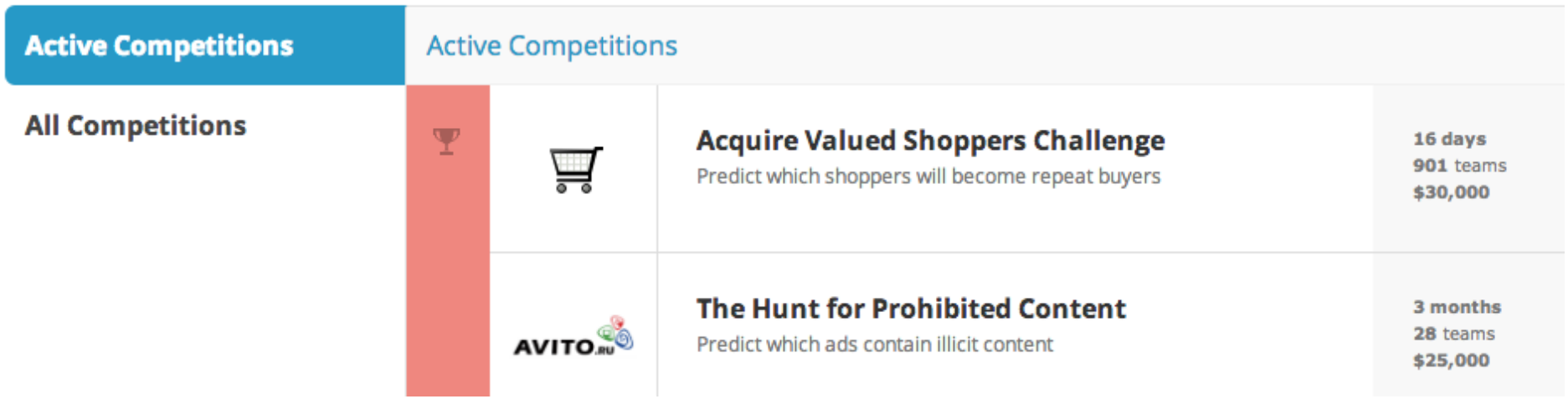


Recommender systems: movie, book, product recommendations

Autonomous vehicles

Spam filtering





A plenty of machine learning competitions

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- Examples:
  - Spam filtering,
  - Handwriting recognition,
  - Text classification,
  - Stock prices,
  - etc.

Machine learning

- We know relatively much about solving simple learning problems such as binary classification:
  - Advanced theory,
  - Implemented fast algorithms,
  - Almost a mature technology.
- The main challenges are:
  - feature engineering,
  - supervision of examples,
  - new applications,
  - new complex problems,
  - large-scale problems.

The aim and scope of this lecture

- **Aim**: To explain theoretical foundations of machine learning in order to show how simple algorithms can be used for solving complex problems.
- **Scope**:
  1. Introduction to Machine Learning
  2. Binary Classification
  3. Bipartite Ranking
  4. Multi-Label Classification

Bibliography

- T. Hastie, R. Tibshirani, and J.H. Friedman. *Elements of Statistical Learning: Data Mining, Inference, and Prediction*. Springer, second edition, 2009
  `http://www-stat.stanford.edu/~tibs/ElemStatLearn/`
- Christopher M. Bishop. *Christopher M. Bishop*. Springer-Verlag, 2006
- David Barber. *Bayesian Reasoning and Machine Learning*. Cambridge University Press, 2012
  `http://www.cs.ucl.ac.uk/staff/d.barber/brml/`
- Yaser S. Abu-Mostafa, Malik Magdon-Ismail, and Hsuan-Tien Lin. *Learning From Data*. AMLBook, 2012

Software

- Weka (`http://www.cs.waikato.ac.nz/ml/weka/`)
- R-project (`http://www.r-project.org/`),
- Octave (`https://www.gnu.org/software/octave/`),
- Julia (`http://julialang.org/`),
- Scikit-learn (`http://scikit-learn.org/stable/`)
- Matlab (`http://www.mathworks.com/products/matlab/`)
- H20 (`http://0xdata.com/`)
- GraphLab (`http://dato.com/`)
- MLLib (`https://spark.apache.org/mllib/`)
- Mahout (`http://mahout.apache.org/`)
- ...