

Innovation through algorithms that learn

an introductory talk—what is it, what can we do

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(IDSIA, Lugano)



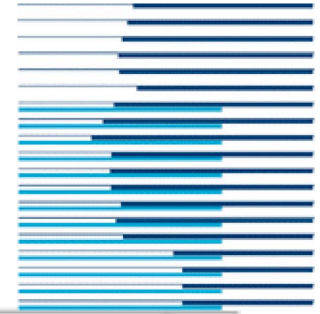
Lugano



Università della Svizzera italiana

Scuola universitaria professionale
della Svizzera italiana

IDSIA
Istituto Dalle Molle di studi
sull'intelligenza artificiale



IDSIA is a research institute on
Artificial Intelligence
founded in 1988 in Lugano



Now about 60 people:
7 Professors, 26 PostDocs/Sw Engineers
19 PhD students, 6 Master students

Thanks to italian philanthropist
Angelo Dalle Molle
(1908-2002)



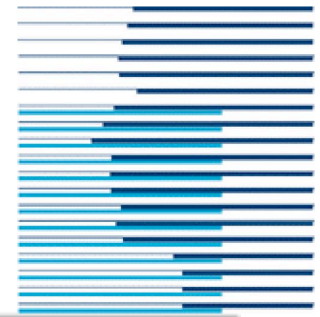
IDSIA affiliated with
USI and SUPSI since 2000



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IDSIA
Istituto Dalle Molle di studi
sull'intelligenza artificiale



Research areas

- Artificial neural networks, vision
- Uncertain reasoning and data mining/statistics
- Cognitive and mobile robotics
- Optimisation, simulation and decision support systems

Basic research (Swiss National Science Foundation)

European projects

Applied research (CTI, direct mandates)

Teaching (SUPSI, USI)

Many ways of learning

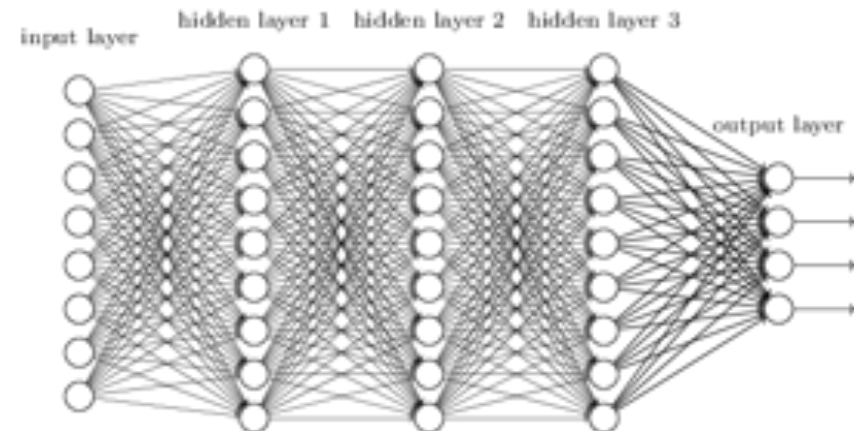
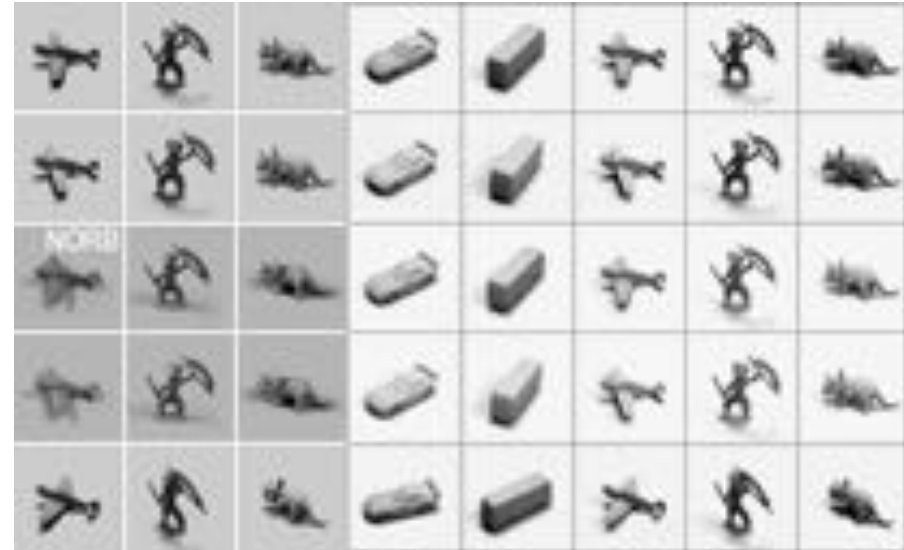
Learning

- “Learning” can mean many things
- I propose a wide view of learning in this talk
- We will go through different ways of learning and their possible applications

Artificial vision and deep neural networks

Artificial vision & neural nets

- Artificial vision
 - is fundamental in many practical applications
 - future systems will be based more on images than on texts
 - robots have to understand their environment
 - automatic classification for medical, navigation, recognition
- Neural networks
 - inspired by the human brain (tiny compared to it)
 - universal function approximators
 - deep = sort of “big” nets = sort of resurrection of these models
 - often thanks to hardware speedup



Drones

MAV Navigation in the Forests Trail Following under the Tree Canopy



IDSIA, Lugano, Switzerland
RPG, University of Zurich, Switzerland
<http://www.bit.ly/perceivingtrails>



Swiss National
Centre of Competence
in Research



Learning from images: challenges



Use GPU parallelism to learn faster



ICDAR 2011 Chinese chars recognition (1st)

IJCNN 2011 Online traffic sign recognition (1st & 2nd rank)

NORB Object recognition renchmark. New record (2.53% error rate), January 2011

CIFAR-10 Object recognition. New record (19.51% error rate), January 2011

MNIST Handwritten digit recognition. New record (0.35% error rate) in 2010, January 2011, improved (0.31%) in 2011

...

...



Knowledge transfer



KTI/CTI

AEA-App-Sachwert
Antrag auf fondsgebundene Rentenversicherung /
Antrag auf Kostengleichvereinbarung

AEAL

D-0905-3
M2X2-F3

1803,977

180,0774, Jens

08. Feb. 2007

1800,- € 1800 €

Beitrag in EUR 70,- 70,0

Wohnort Berlin Berlin

IFF - Intelligent Fill in Form Project



Success story

Google to acquire artificial intelligence company Deep Mind

Monday, Jan 27 2014, 10:57 GMT

Google is reportedly close to acquiring artificial intelligence company Deep Mind.

The web giant has agreed to pay \$500 million (£302m) for the London-based startup

DeepMind is a cutting edge artificial intelligence company. We combine the best techniques from machine learning and systems neuroscience to build powerful general-purpose learning algorithms.



LUGANO - Si chiama Shane Legg, ha conseguito il suo dottorato di ricerca presso l'Istituto Dalle Molle di studi sull'intelligenza artificiale ed è uno dei tre fondatori di DeepMind ...

SUPSI

English/Italiano AL/Info [Database/Info](#)

- > SUPSI
- > Bachelor, Diploma and Master
- > Continuing education
- > Research

Profession and Passion

CaEline Cornetti, Student, Engineering and Management. Flexibility, versatility, inter-disciplinarity and technology are future of tomorrow.

People directory

NEW SEARCH

Person

Name, Surname or phone number

Unit

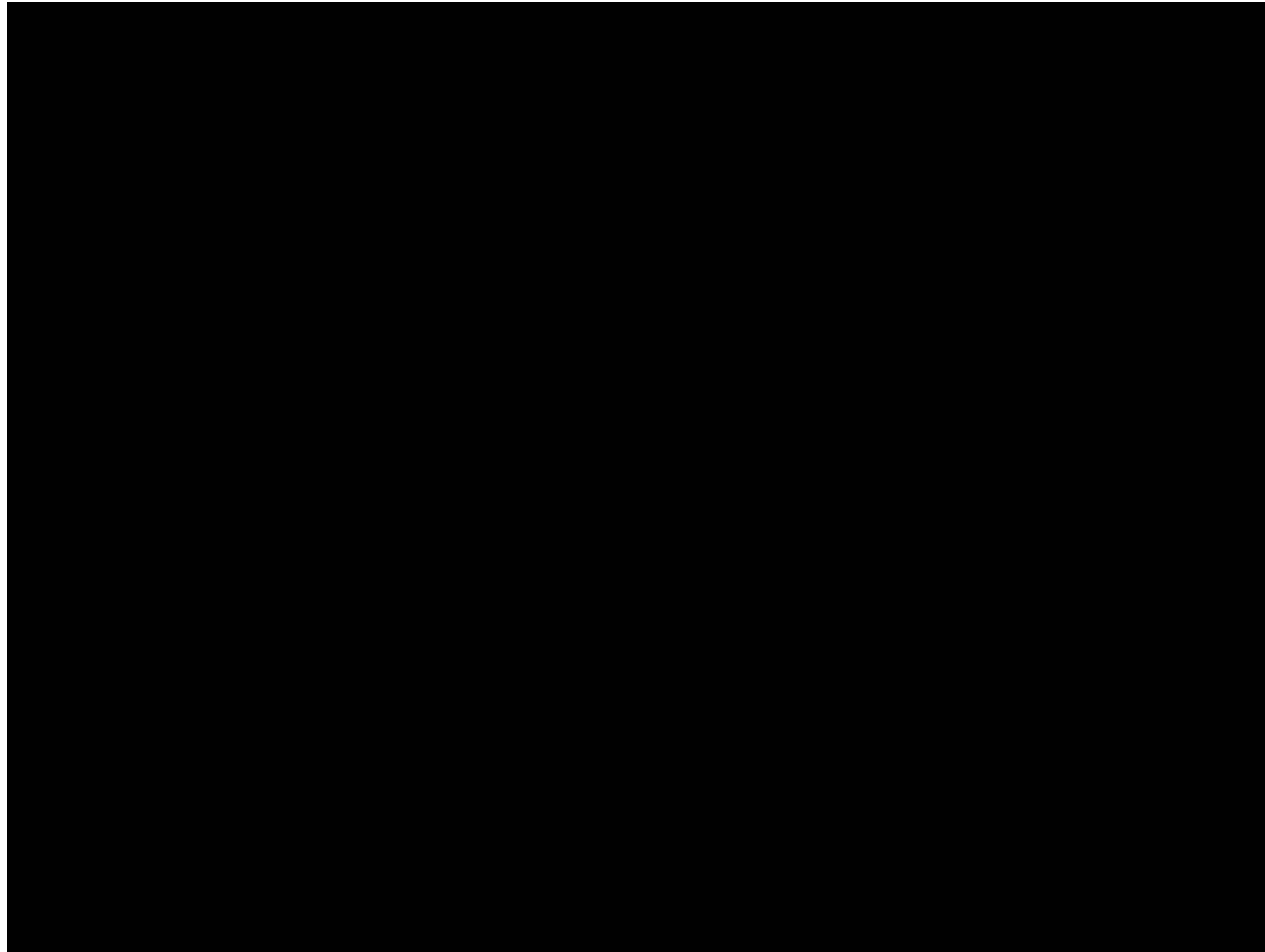
AI

Search details

Contacts	Publications	Research Projects
Name and Surname	Shane Legg	
Department/School/Unit	Dalle Molle Institute for Artificial Intelligence	

Send card by email

DeepMind – *Nature*: 26 Feb 2015



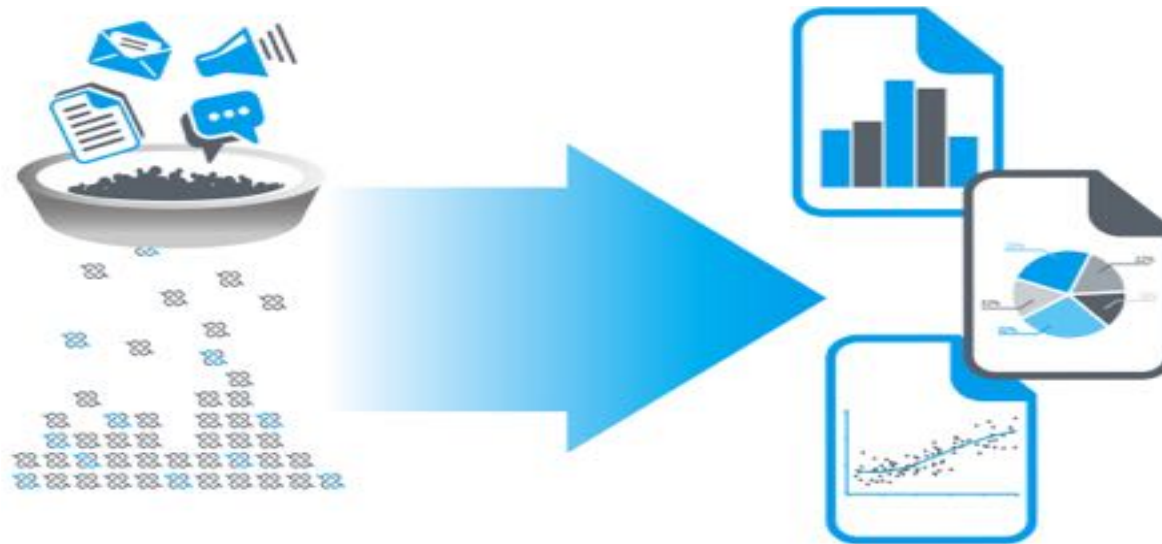
Learning from data (data mining)

(Unstructured) Data

- Numbers
- Chars/texts
- Sounds
- Images/clips
- Graphs
- DNA ...

Learning from data

- Search for patterns in data

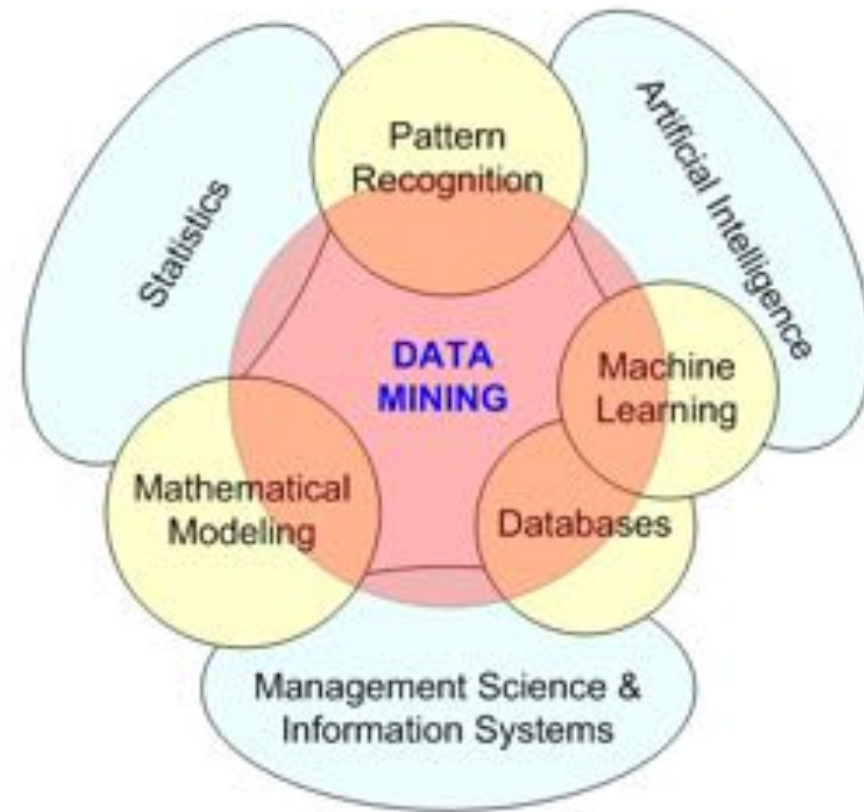


- set of patterns = a **model**
- allows us to structure information
- Models **can be queried**
 - for prediction, diagnosis, recognition, ...
- (Sort of) Domain independent
 - the meaning of data is not always needed



Methods and algorithms

- A few of them:
 - ...
 - Neural networks
 - Probabilistic networks
 - Causal graphs
 - Classifiers
 - Regression
 - Bayesian statistics
 - Cluster analysis
 - ...



And big data?

“Big data is like teenage sex: everyone talks about it, nobody really knows how to do it, everyone thinks everyone else is doing it, so everyone claims they are doing it ...”

– Dan Ariely

Big data

- Gartner and the 3 V's:
 - Volume, Velocity, Variety
 - business intelligence?
 - focus on data description/synthesis
- Big data focuses on:
 - inductive learning
 - complex techniques (non-linear, multivariate, ...)
- In need of new forms of analysis
 - e.g., very fast algorithms



Challenges

“If you torture the data long enough, they will confess anything.”
– Ronald Coase

Challenges

- New hw and sw infrastructures
- **A lot** of mathematics
- Feature engineering
- Overfitting
- Scarse data
- High dimensionality
- ... and much more ...



MODERN DATA SCIENTIST

Data Scientist, the sexiest job of the 21st century, requires a mixture of multidisciplinary skills ranging from an intersection of mathematics, statistics, computer science, communication and business. Finding a data scientist is hard. Finding people who understand who a data scientist is, is equally hard. So here is a little cheat sheet on who the modern data scientist really is.

MATH & STATISTICS

- ☆ Machine learning
- ☆ Statistical modeling
- ☆ Experiment design
- ☆ Bayesian inference
- ☆ Supervised learning: decision trees, random forests, logistic regression
- ☆ Unsupervised learning: clustering, dimensionality reduction
- ☆ Optimization: gradient descent and variants

DOMAIN KNOWLEDGE & SOFT SKILLS

- ☆ Passionate about the business
- ☆ Curious about data
- ☆ Influence without authority
- ☆ Hacker mindset
- ☆ Problem solver
- ☆ Strategic, proactive, creative, innovative and collaborative



PROGRAMMING & DATABASE

- ☆ Computer science fundamentals
- ☆ Scripting language e.g. Python
- ☆ Statistical computing packages, e.g. R
- ☆ Databases: SQL and NoSQL
- ☆ Relational algebra
- ☆ Parallel databases and parallel query processing
- ☆ MapReduce concepts
- ☆ Hadoop and Hive/Pig
- ☆ Custom reducers
- ☆ Experience with xaaS like AWS

COMMUNICATION & VISUALIZATION

- ☆ Able to engage with senior management
- ☆ Story telling skills
- ☆ Translate data-driven insights into decisions and actions
- ☆ Visual art design
- ☆ R packages like ggplot or lattice
- ☆ Knowledge of any of visualization tools e.g. Flare, D3.js, Tableau

A few applications



Efficient



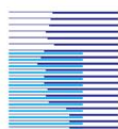
Automated



Scalable

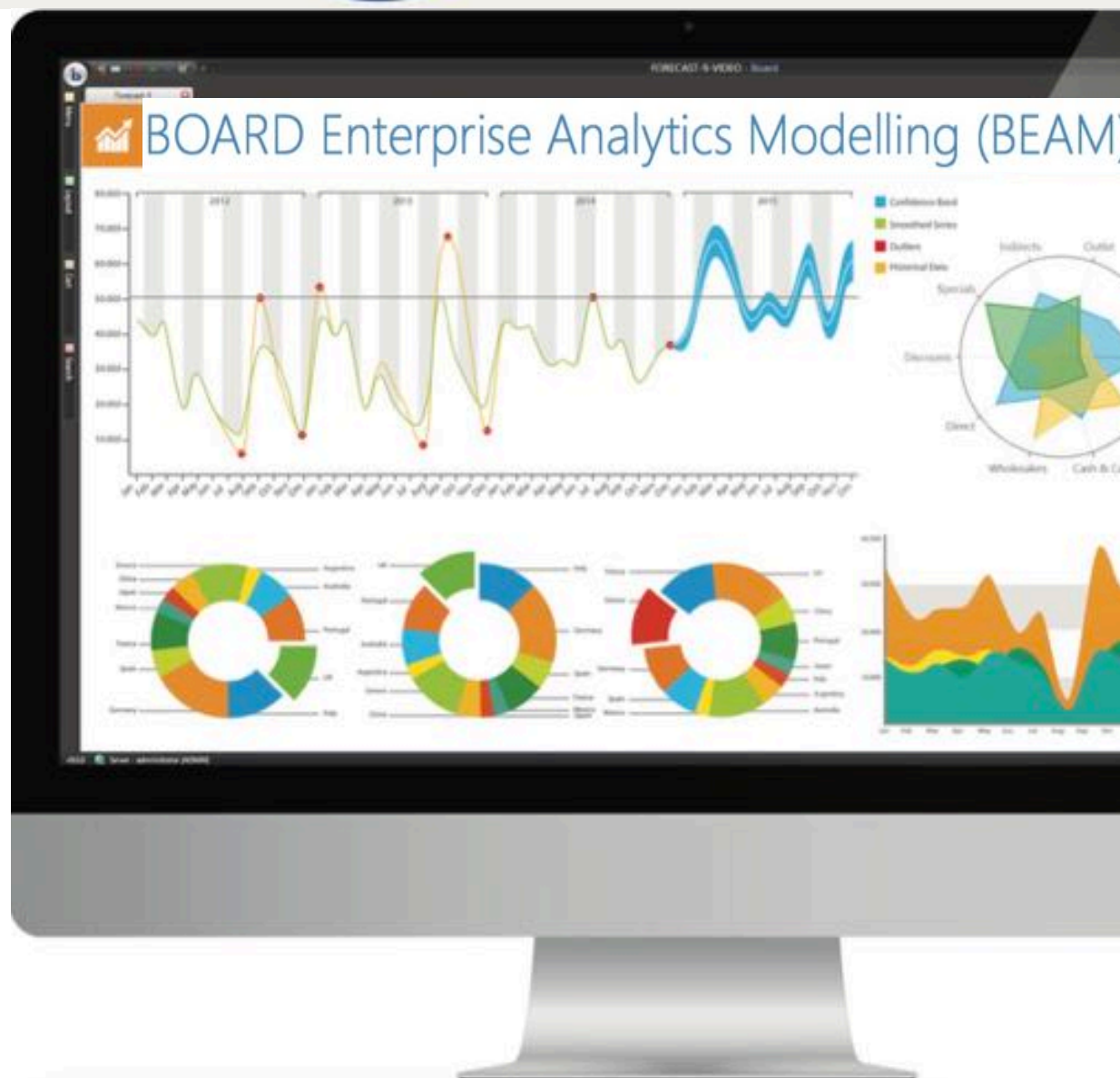
KTI/CTI

USI/SUPSI



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+GF+
GEORG FISCHER



electro-discharge
machining



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... and more ...



KTI/CTI

– predict value of portfolio of **non-performing loans**

hoosh

KTI/CTI

– **visibility score** by Google search results

Medigest KTI/CTI

– investments, over-the-counter **financial tools**



– **genetic analysis** on lymphomas

...

Learning from experts

Good old “expert systems”

- **Learning from experts**
 - by interviews, simulated data, etc.
 - ideas similar to “old” expert systems but:
 - new techniques (e.g., probabilistic graphical models)
 - easy to use, powerful, reliable
 - for strategic analysis, decision support

The **arma**suisse collaboration

- No-fly zone



- Identifying intruder's goal



renegade



provocateur



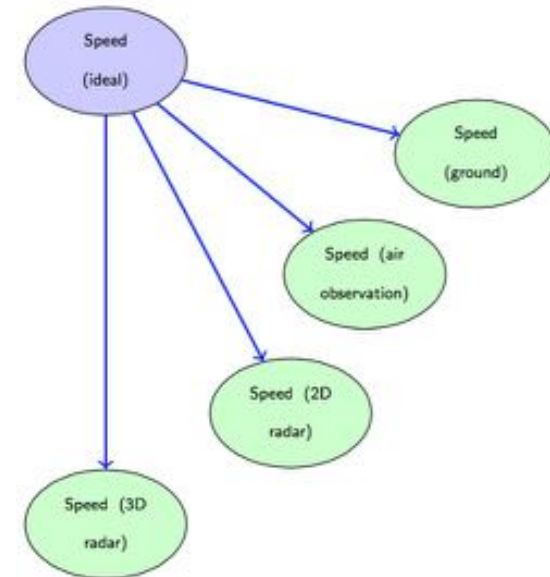
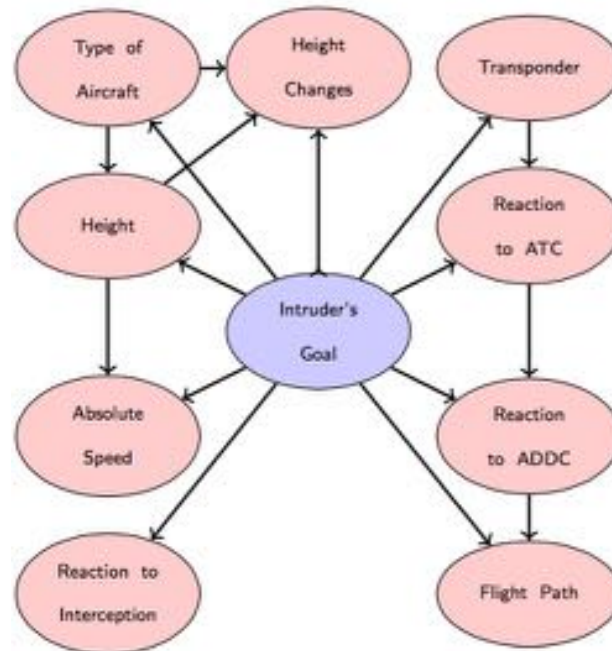
damaged



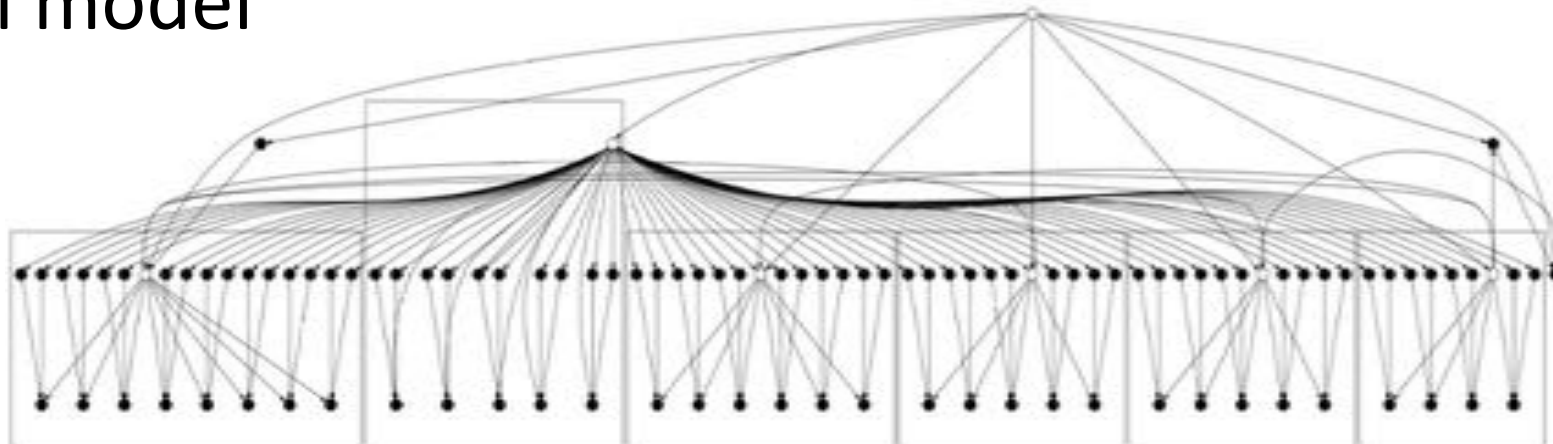
erroneous

The **arma** suisse collaboration

- Core models



- Full model



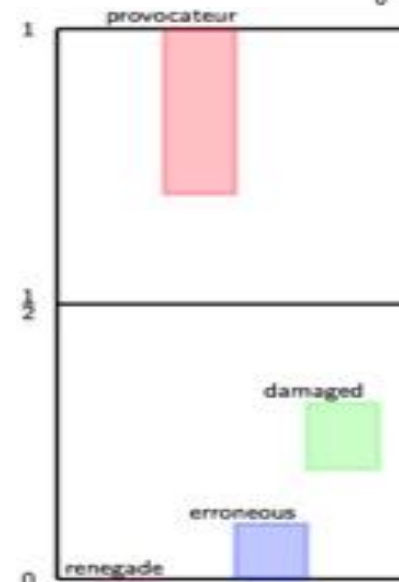
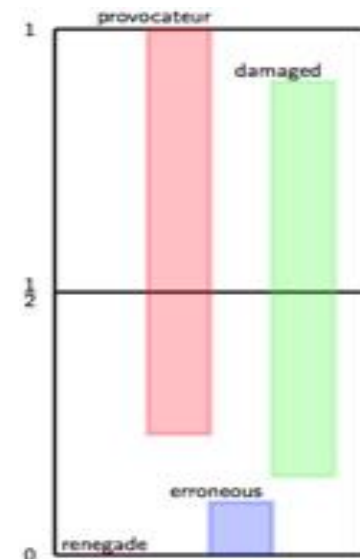
The suisse collaboration

- Queries

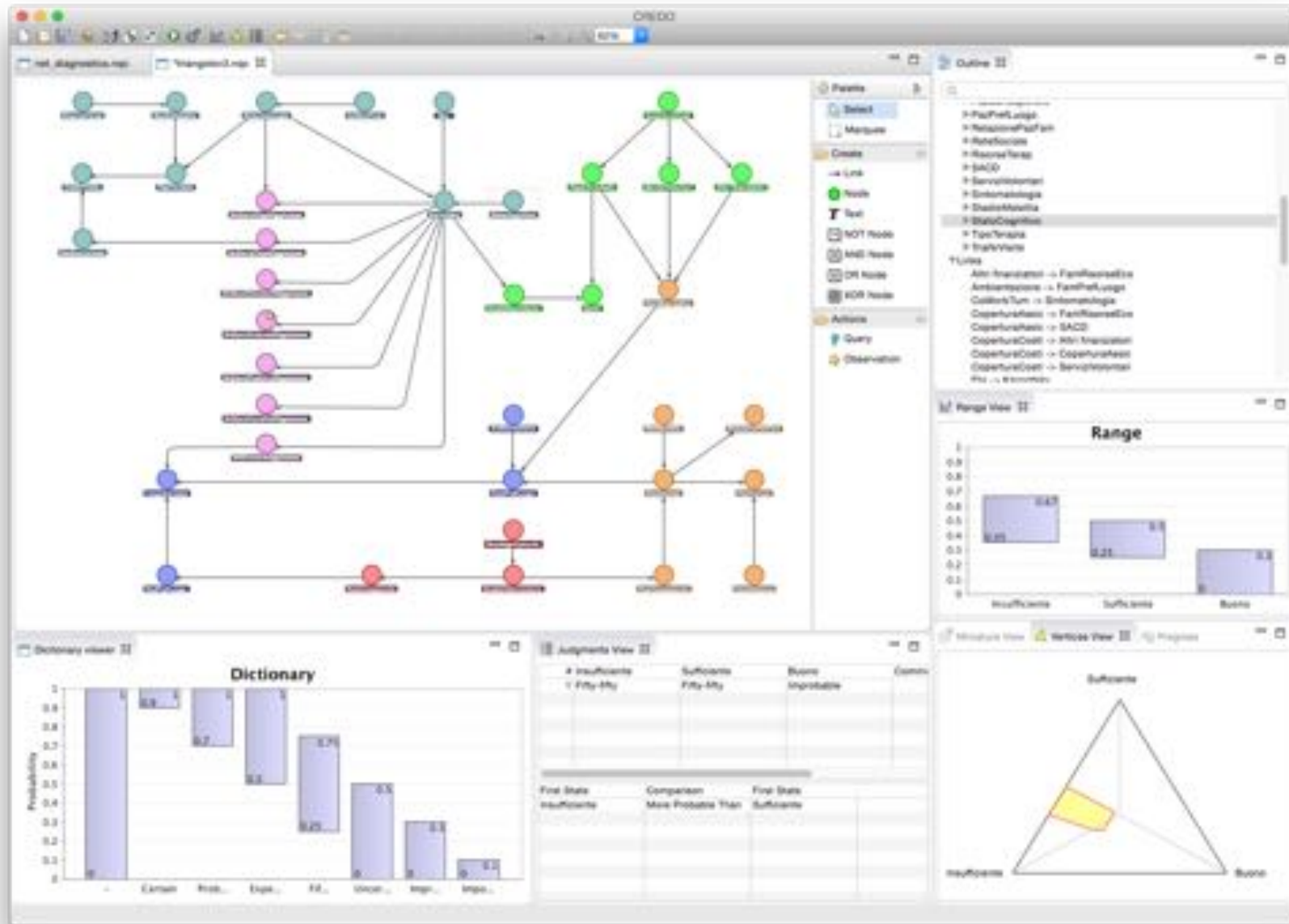
- simulating a dam in the Swiss Alps, with no interceptors, relatively good coverage for other sensors, discontinuous low clouds and daylight

- height = low, type = helicopter, flight path = U-path, height changes = descent, speed = slow, ADDC reaction = positive

- height = very low, type = helicopter, flight path = U-path, height changes = descent, speed = slow, ADDC reaction = negative



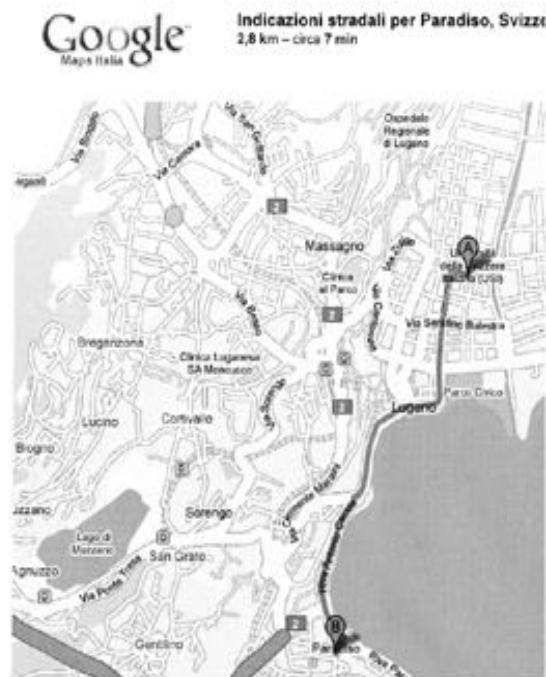
The **arma** suisse collaboration:



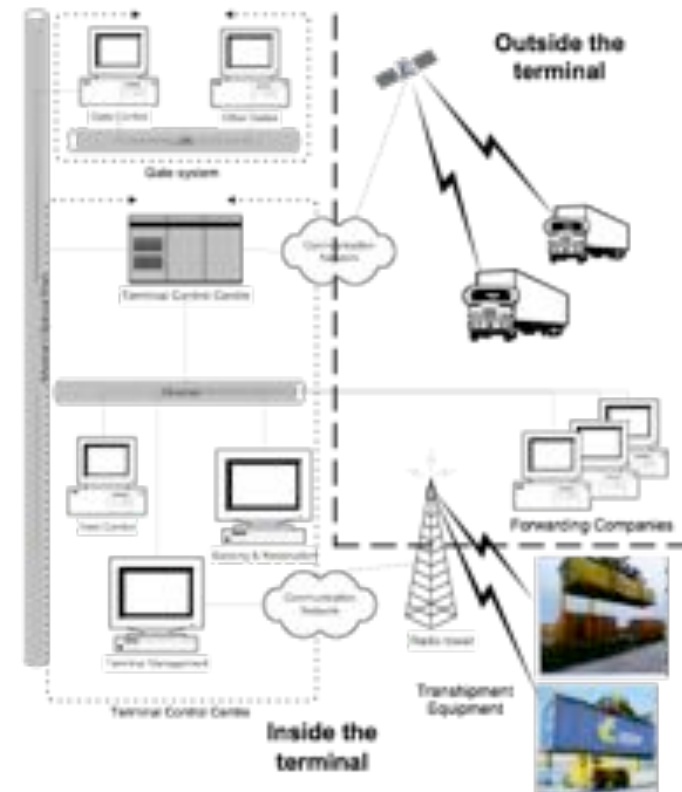
Learning to optimise

Optimisation

- **What:** logistics, production, scheduling, routing, planning ...
- **Goal:** good solutions in short time under uncertain information



2



How ants learn the best path to food



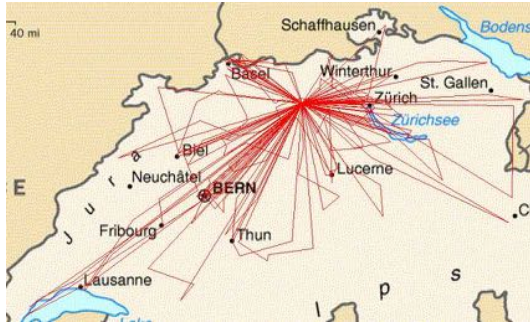
Results



The New York Times
ON THE WEB



Industrial applications



Vehicle routing for
Migros
(300 Trucks)



HUPAC
moving together

Trains
Optimisation

*ticino***transfer**
rete per il trasferimento di tecnologia
e del sapere della Svizzera italiana



Vehicle routing for
BARILLA
(1200 Trucks)

KTI/CTI



Terminal Optimisation

Collective intelligence



Distributed and swarm robotics:

3D robotic swarm inspired by insects: flying robots (eyes), climbing robot (hands),
mobile robots (foot)





3D swarm



Summarising

- **Machines can learn and are a huge opportunity for innovation**
 - data, in particular, as the petrol of the 21st century
 - we are only at the beginnings
- **Yet, let's not be fooled: the human factor is fundamental**
 - data and algorithms are just new tools *for us*
 - algorithms can suggest the best action, but we do create the options
 - the responsibility of important decisions is (even more) on us
- **Algorithms don't go far away without scientists**
 - what you need are first (data) scientists, only then algorithms
 - not PhD students but experienced postdoc researchers
 - tight, continued, connection with university is fundamental
 - **but scientists do need to be able to talk to industry**