A.I.
A Genie in the Bottle?

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What is A.I.?
What is Intelligence?

Intelligence is the ability to understand or to make sense and to act accordingly.
More than 4B years start-up time
2.5M years from Homo to present day man
One ultimate goal: intelligence
25 years of education (~40B p.a. in CH)
Ongoing lifelong learning
One ultimate goal: **intelligence**
Machine intelligence

A topos of human imagination

Automaton vs. Living Being
Very Brief History of A.I.

1950
Theory & Reflection

1960
“Programs”

1970
Symbolic AI Logic

1980
Expert Systems

1990
Neural Networks

2000
Machine Learning

2010
Deep Learning

2017
Intellectual Hope Disappointment Niche Solutions Commercialization Explosion
Challenge #1

A.I. will not stop at the human level
Challenge #2

A.I. may not (just) mimic human skills.
Challenge #3

A.I. will be a networked intelligence
2

Perception
Games of Strategy

How to noblemen display their intelligence?
Man vs. Machine  0 : 1

Computational power
480 chess chips
Brute force search: 200M positions per second

IBM’s Deep Blue vs. Garry Kasparov, 1997
Man vs. Machine  0 : 2

Game of Go not amenable to brute force search \((10^{170} \text{ pos.})\)

Pattern recognition to evaluate positions + self-play for training

Lee Se-dol vs. AlphaGo, March 2017
Ke Jie vs. AlphaGo, May 2017
From Stones to Pixels
Machines that See

Classification error
2011 = 26%
2016 = 3%
Autonomy by Perception

Self-driving cars

Mobileye → Intel 15B$

Tesla (~65B$)

We are excited to announce that, as of today, all Tesla vehicles produced in our factory will have the hardware needed for full self-driving capability at a safety level substantially greater than that of a human driver.

Waymo (~70B$ Morgan-Stanley)
Autonomy by Perception

Self-flying ‘cars’

Airbus (~75B$)

Lilium, Munich (90M$, Series B)

Kitty Hawk, @Larry Page

daedalean.ai, Zürich
14 employees, 2 dogs

One hundred years ago, urban transport went underground, now we have the technological wherewithal to go above ground.

Tom Enders, CEO

"I realized it would be a plus if you didn’t need a pilot licence for your flying car.

Luuk van Dijk
Chief Technology Officer
Autonomy by Perception

Air Delivery

Amazon (470B$): Air Prime

It looks like science fiction, but it's real.

LAWS

lethal autonomous weapons systems

LAWS could violate fundamental principles of human dignity by allowing machines to choose whom to kill
- Stuart Russell, UC Berkeley, 2015
Human Face Recognition

Face recognition / identification

Facebook’s DeepFace (2015)

Sexual orientation
Michal Kosinski et al (2017)

Facial expressions
Super-Human Face Recognition

… over a lifetime
see 1 million faces
remember 3,000

… per day
see 3,000 million faces
remember 3,000 million
Super-Human Vision

**Lip reading** (LipNet, 2016)

LipNet: How easy do you think lipreading is?

https://youtu.be/fa5QGremQf8?t=32

**Leaf reading** (Friedman et al. 2014)

High speed video (actual video playing here)

Sound Recovered From Video

https://www.youtube.com/watch?v=FKXOucXB4a8
Inverting Vision

Synthesizing images  Hjelm et al (2017)

Synthesizing human voice
3
Language
Human Voice Recognition

How many people do you talk to?

Recurrent neural networks
Language & A.I.

Natural Language Processing is the next frontier in A.I.

Yann LeCun, Facebook AI Research, 2015

Philosophy: Language & Thought

It is in names that we think. – Hegel, 1817

The meaning of a word is its use in language. - Wittgenstein, 1953
Man vs. Machine  0 : 3

Jeopardy! Question-Answering
Machine Reading of 200M pages
(3000 years of human reading)
Voting schemes – 100s algorithms

Brad Rutter and Ken Jennings vs. IBM’s Watson in 2011
Embeddings

Idea: represent symbols and discrete structures as **vectors**
Knowledge Graph

Linking text with knowledge representation.

Knowing what is talked about.

Reasoning across billions of documents.
Understanding Sentiment

Automatic sentiment analysis on tweets or reviews.
Machine Translation

Approaching human-level accuracy

Google Research Blog

A Neural Network for Machine Translation, at Production Scale
Tuesday, September 27, 2016

Transformer: A Novel Neural Network Architecture for Language Understanding
Thursday, August 31, 2017
4

Humans
Understanding Behavior

Recommender Systems

Predicting User Behavior

Advertising Platforms

72.5B$ in 2016

[ logos removed ]

Amazon

Netflix

spotify

Youtube

[ logos removed ]

AdWords

Doubleclick

Facebook Ads

AppNexus
Understanding Behavior

Data Management Platform

Predict user attributes and future behavior

DATA COLLECTION → MACHINE LEARNING → STATISTICS

1PLUSX

GENDER
AGE
INTERESTS
CUSTOM ATTRIBUTES

ETH Zürich
Understanding Behavior

70 likes = friend
150 likes = family member
300 likes = spouse

[Youyou et al. 2015]

Psychometrics

Big Data + Big Gov = ?

www.wired.co.uk/article/chinese-government-social-credit-score-privacy-invasion
5

Outlook
Deciphering the code of life

A.I. for Personalized Health

Fusion across many modalities
Decision support

Courtesy Gunnar Rätsch, ETHZ
Strategy & Uncertainty

Visual interpretation of Arcade game “scenes”

Understanding of effect of actions, reinforcement learning (deep Q-learning)

DeepMind Atari bot playing Montezuma's Revenge, 2016

Google acquired DeepMind for 660M$ in 2014. Value today – priceless ;-)
Complex Decision Making

Helping clinicians get patients from test to treatment, faster

We set up DeepMind Health to put the UK’s most advanced technology at the service of patients, nurses and doctors.

The NHS does an amazing job under enormous pressure. Most people get truly world-class care, but every single day patients suffer avoidable life-changing conditions and even die because they don’t get the right treatment in time. Nurses and doctors in the NHS and elsewhere simply don’t have the tools to instantly analyse each test result, determine the right treatment, and make sure that every single patient who needs complex or urgent care is escalated to the right specialist immediately.

Emergency room monitoring

Administration & Processes

Drug Screening
6 Reflections
Statistical (& Causal) Models

Statistical Model: dependencies between
observables (data), actions (causal), and outcomes.

Good old days
linear regression

Today's complex, Deep models
"perception-like"
10-100Ms of parameters
Interpretability & Trust

Limits of understandability
- Mechanism & model complexity
- Variability of each instance
- Unpredictable environment & interactions

Approaches
- Empirical validation
- Testing (instead of ‘specification’)
- Build-in guarantees, objectives

Norbert Wiener, 1960

[…] we had better be quite sure that the purpose put into the machine is the purpose which we really desire and not merely a colorful imitation of it.