The Business School for the World®

AI, Organizations, Society

(and some research directions)

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Technological Innovations for Business: 1990s to Today

- Early/Mid 1990s: **Enterprise Resource Planning** (e.g. SAP, Oracle, etc.) – Business Process Re-engineering, process automation and support
- Mid/Late 1990s: **Internet** – networks, global connectivity, information capturing/sharing, increased "richness and reach", virtual teams, etc.
- Early 2000s: **Knowledge Management** – capture, share, reuse, connect internal knowledge, experts, best practices, etc.
- Early/Mid 2000s: **Customer/Supplier/etc. Relationship Management** – acquire, manage, understand, cross/up-sell, retain customers/suppliers/etc.
- Late 2000s/Early 2010s: **Big Data + Cloud** – the last step before…

All previous technologies were at best decision support tools

AI can take increasingly complex decisions (…and facilitate discoveries…)

Big Data *vs* Machine Learning *vs* AI [watch video]

Learning is at the Core of Intelligence

Experience + Learning → (Human) Intelligence

Experience for Humans = (Big) Data for Machines

(Big) Data + Machine Learning → Artificial Intelligence

Example Use Cases

Credit Scoring
(since the 80s – HNC's "Database Mining Workstation")

Recommender Systems and cross-selling
(Amazon/Netflix/etc. since the 90s)

Churn Management
(with ML/AI since the early 2000s)

Targeted advertisement and campaigns
(since early 2000s)

… other ***Customer Relationship Management*** **(Marketing)** decisions...

The Early Days…

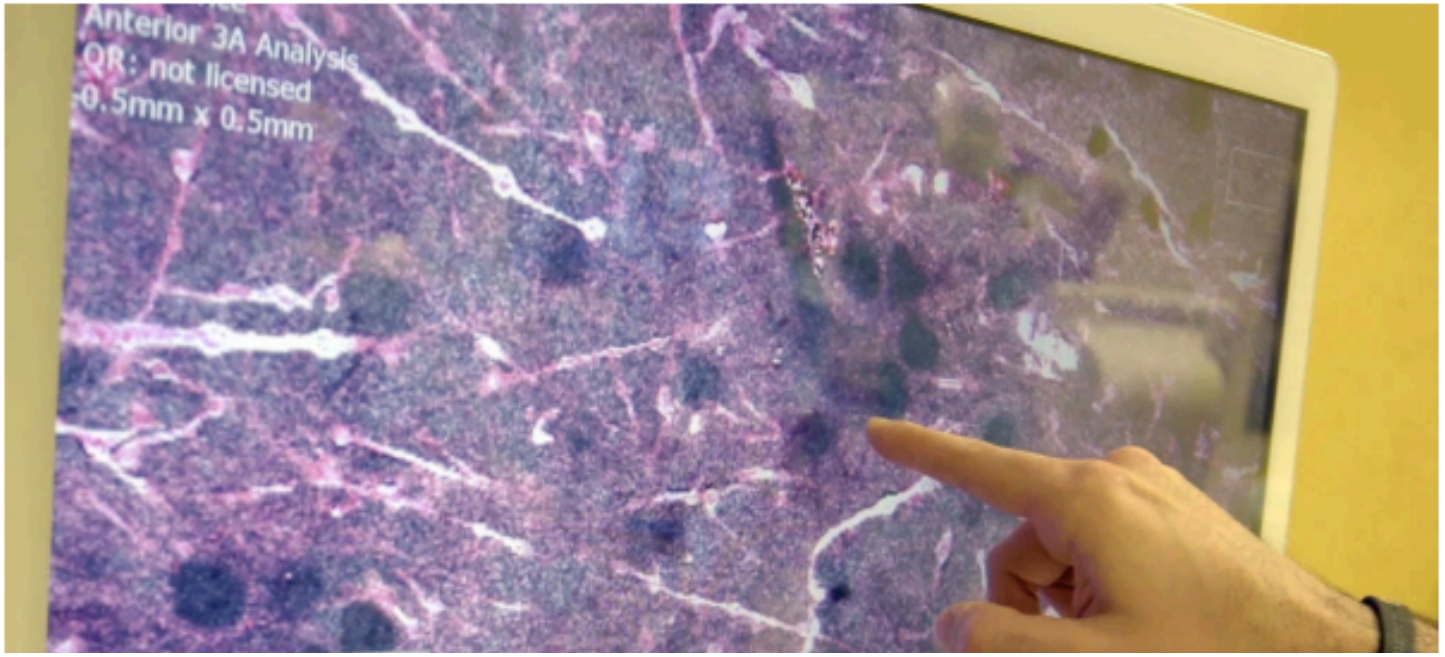
...And now?

The New York Times

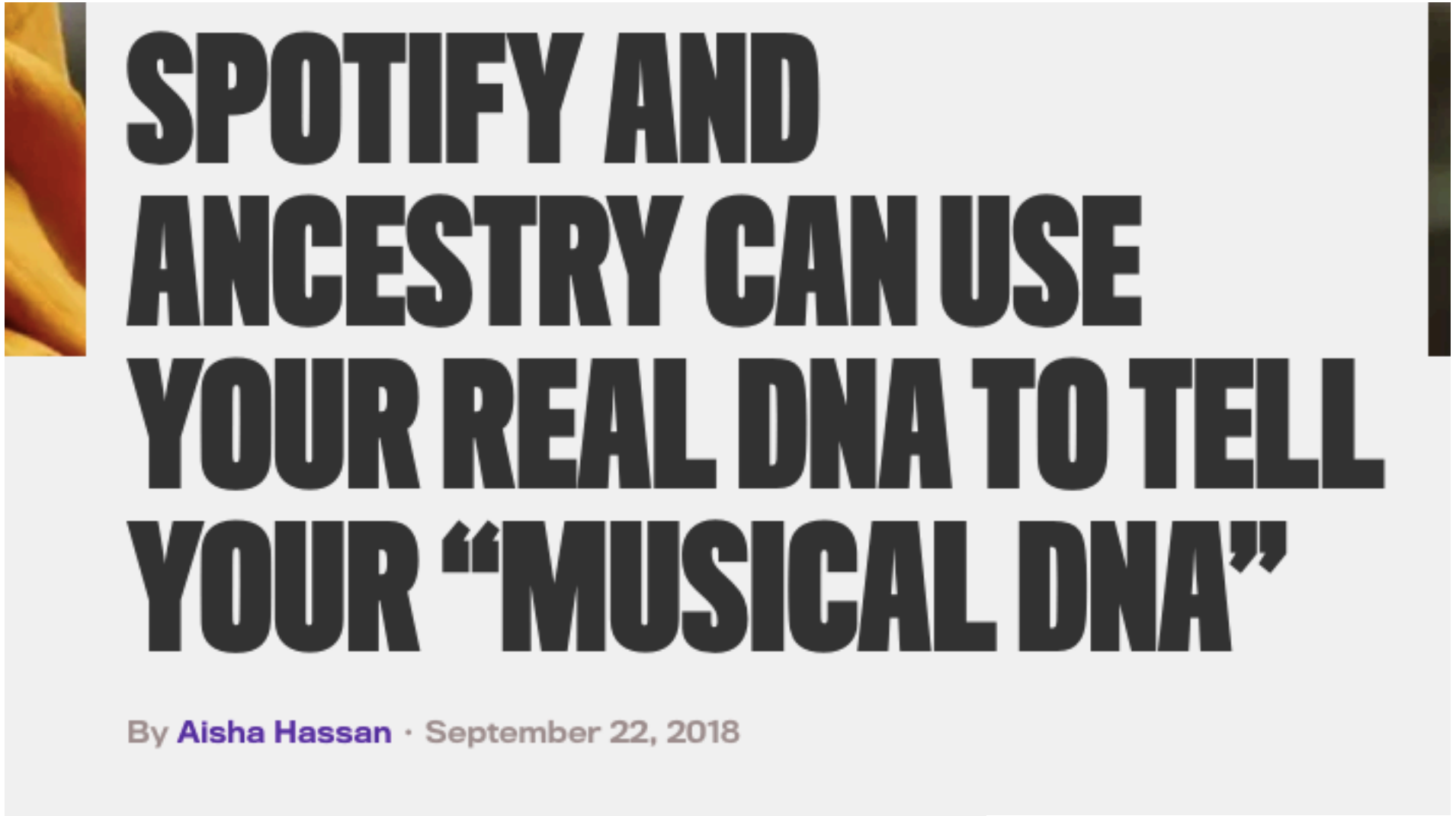
A.I. Comes to the Operating Room

Images made by lasers and read by computers can help speed up the diagnosis of brain tumors during surgery.

Jan. 6, 2020



The traditional method, which requires sending the tissue to a lab, freezing and staining it, then peering at it through a microscope, takes 20 to 30 minutes or longer. The new technique takes two and a half minutes. Like the old method, it requires that tissue be



SPOTIFY AND ANCESTRY CAN USE YOUR REAL DNA TO TELL YOUR "MUSICAL DNA"

By Aisha Hassan · September 22, 2018

FORTUNE

MIT Technology Review

Can an AI be an inventor? Not yet.

INSEAD

But some campaigners are pushing for the rules to change.

by **Angela Chen**

Jan 8, 2020

Most of the time, artificial intelligence is simply a tool that helps inventors— for example, by synthesizing enormous data sets to find promising drugs or discover new materials. But what would happen if it were fully responsible for the act of invention itself?

that doesn't necessarily mean everything an AI creates can or should be traced back to humans. Hundreds or thousands of people might be involved in programming

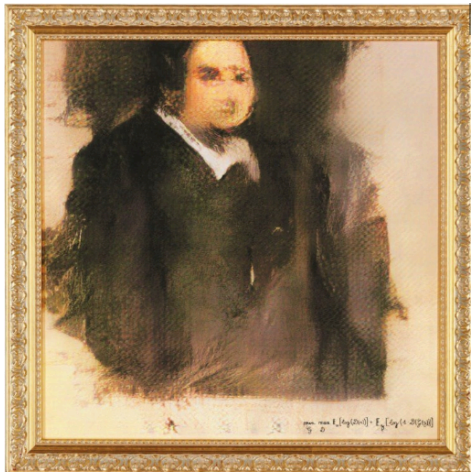
towardsdatascience.com/supercreativity-b4114ebd0357

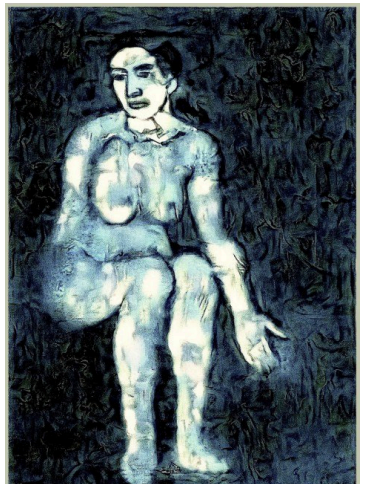
Supercreativity

AI may soon surpass human artistic creativity

Article link

Serafim Batzoglou and Theodoros Evgeniou





human-AI collaboration processes. As Sebastian Thrun puts it, "*we have not even begun to understand how creative AI will become. If you take all the world's knowledge and creativity and put it into a bottle, you will be amazed by what will come out of it*".

But….

Intelligent Machines

How to Root Out Hidden Biases in AI

"We can't rely on machine learning to stop another **financial crisis** - In fact, overreliance on **AI and big data could lead to the next one**"

THE FUTURE OF EVERYTHING

Don't Believe the Algorithm

Blind faith in machines (and machine learning) has left us vulnerable to biased and incoherent AI. The solution? A healthy dose of skepticism and human oversight.

By Hannah Fry
Sept. 5, 2018 10:27 a.m. ET

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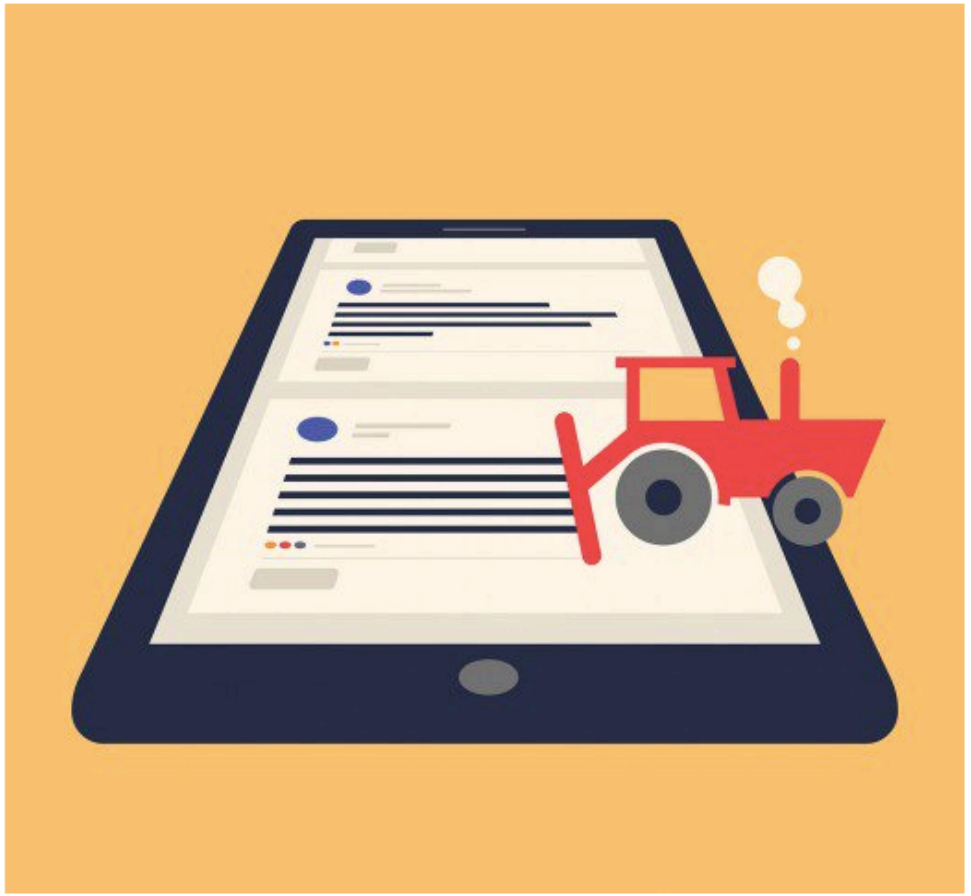
Intelligent Machines

Future elections may be swayed by intelligent, weaponized chatbots

The AI advances that brought you Alexa are teaching propaganda how to talk.

by Lisa-Maria Neudert August 22, 2018



MAGOZ

MIT Technology Review

And (much) more to come…..

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nature
International journal of science

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NEWS · 24 APRIL 2019

Brain signals translated into speech using artificial intelligence

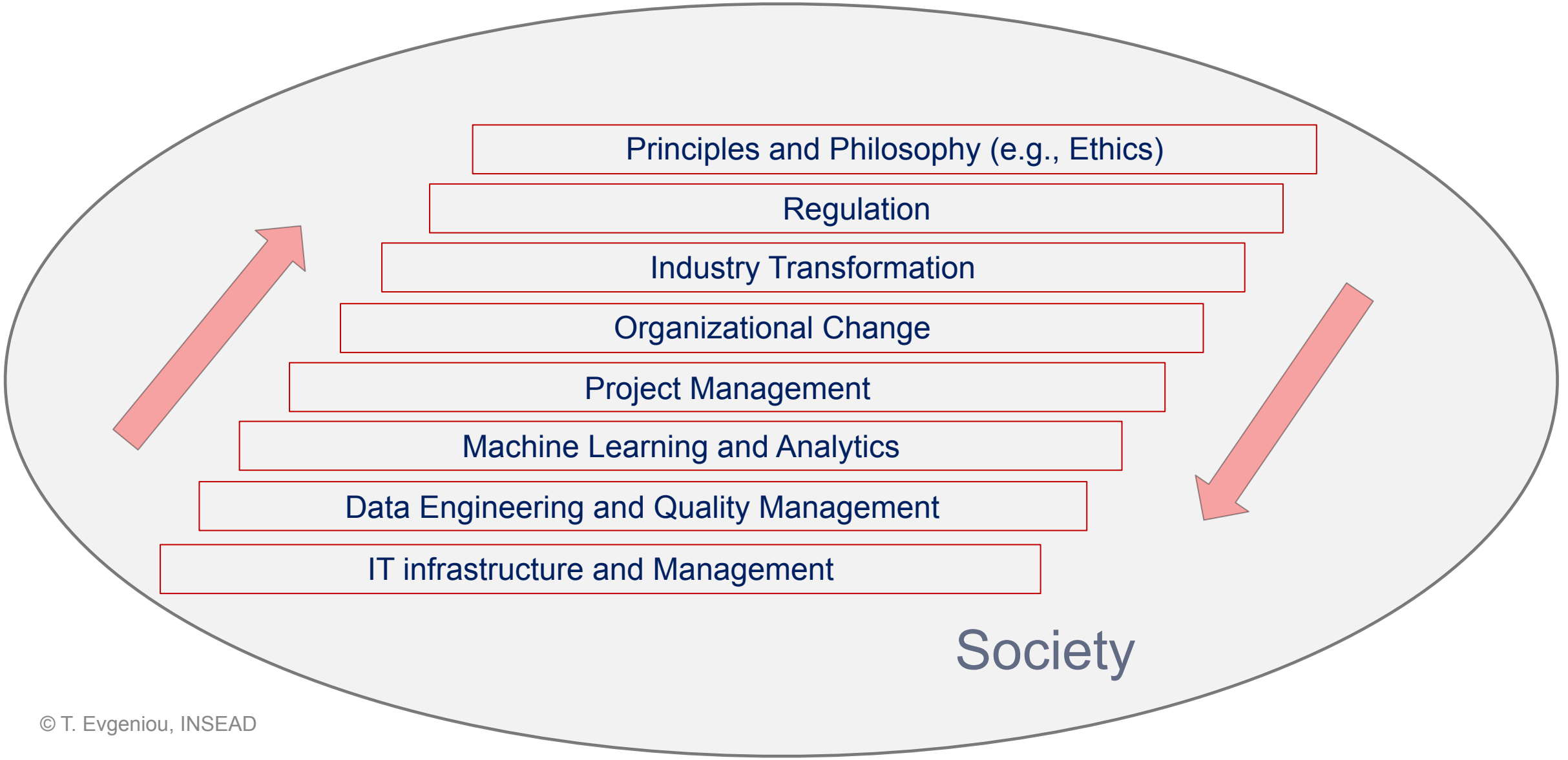
Technology could one day be used to help people who can't talk to communicate.

AI, more than any other technology, requires a more

Holistic Approach

[Watch Video]

A Key Message:
AI requires a *Holistic Approach*



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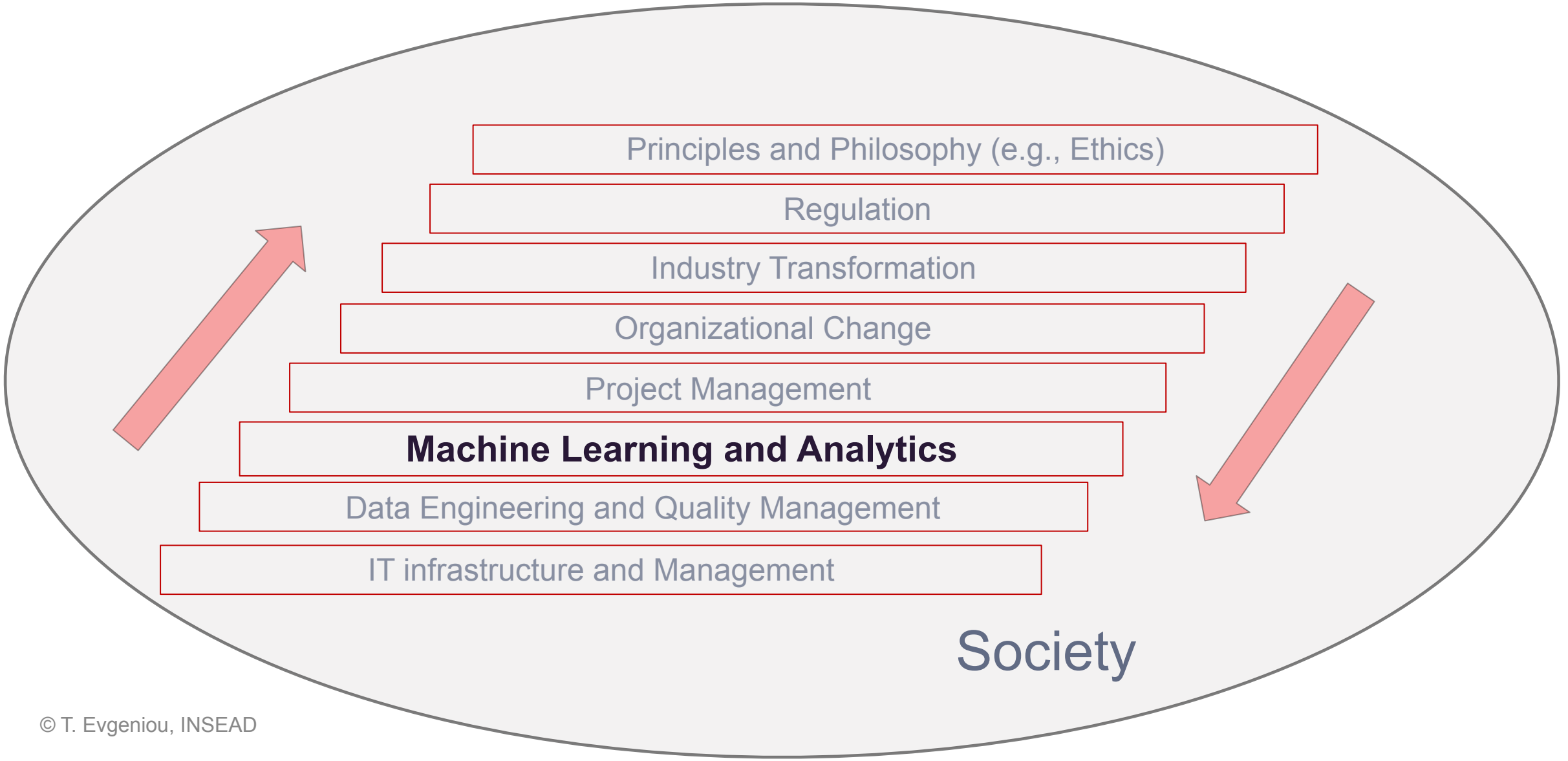
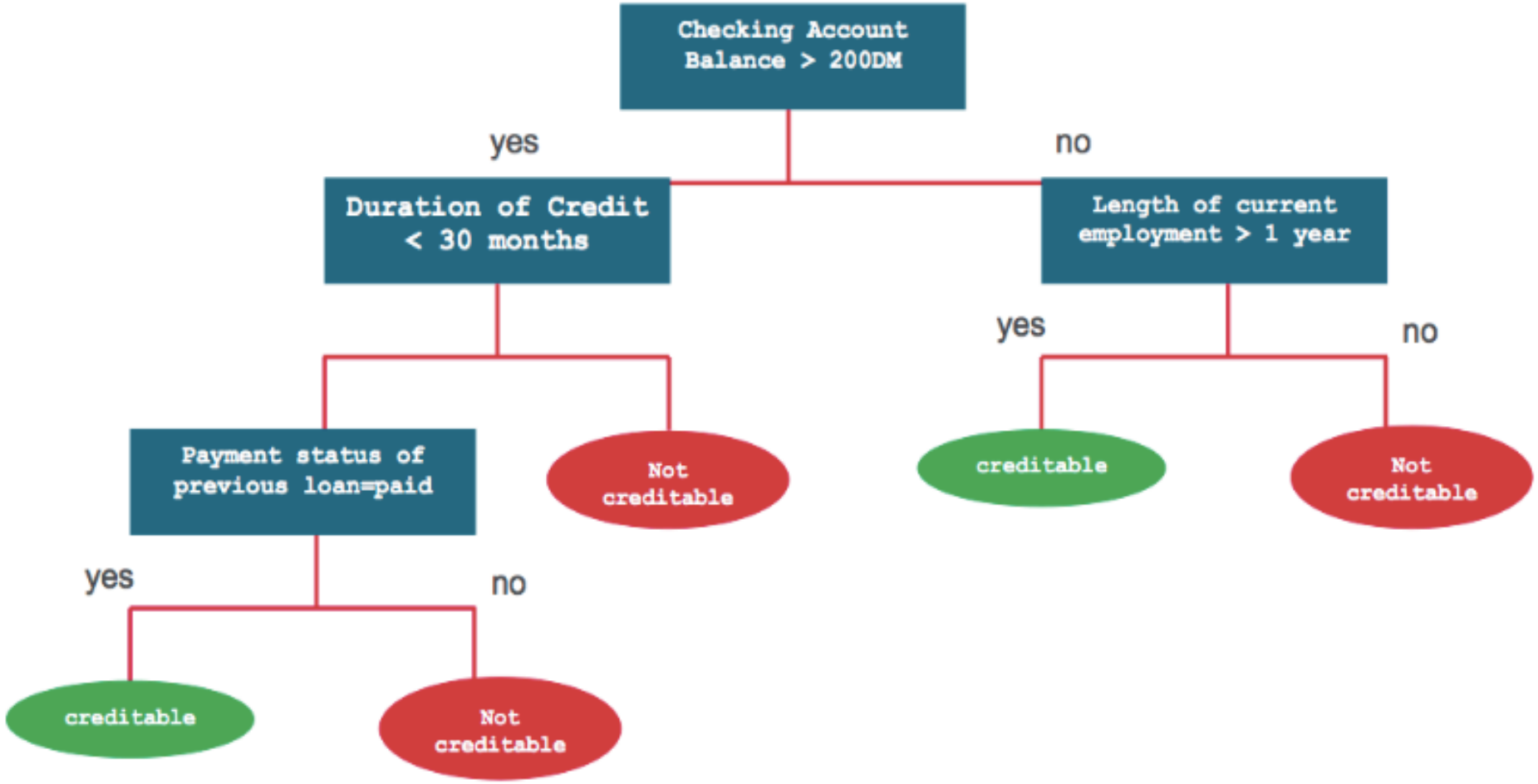


Don’t Shy Away from “Simple Rules”…

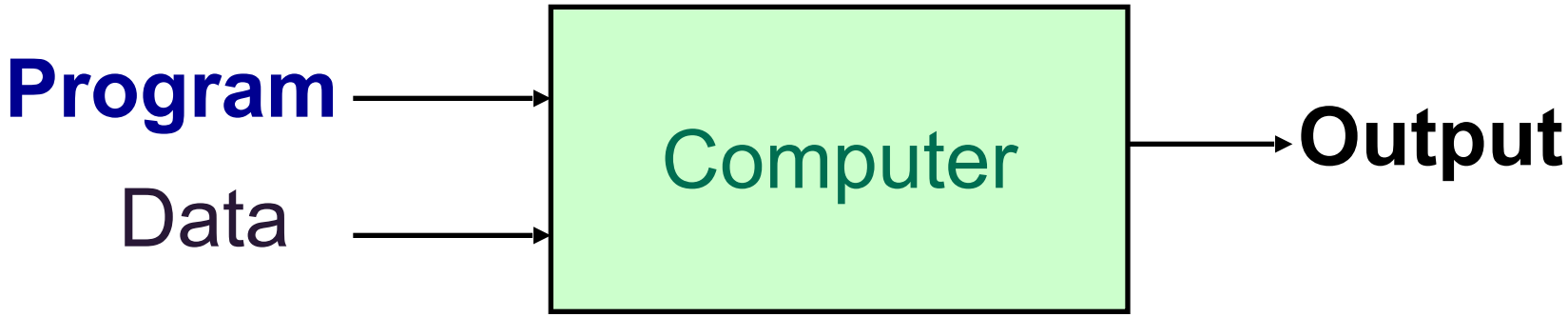


Rules... Is this how *Humans* (often) decide? [Article link]

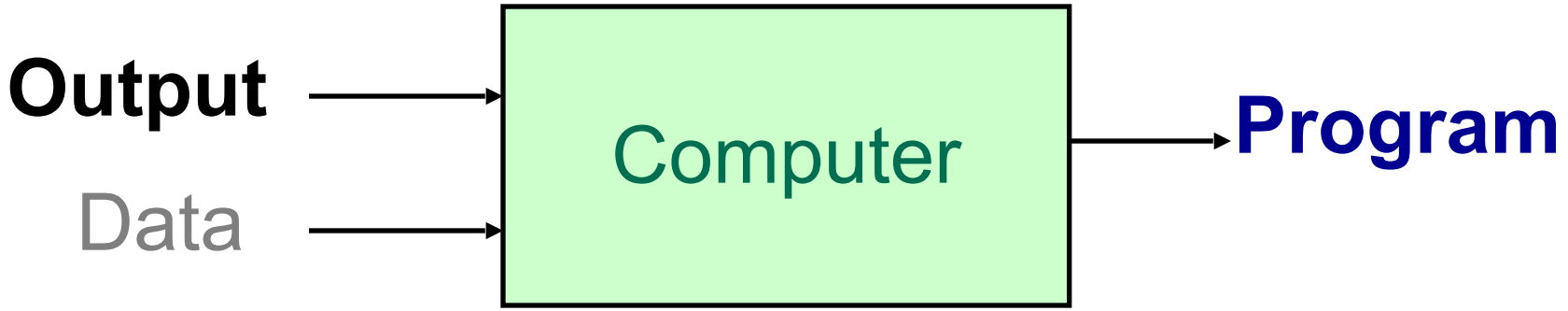
- (Light AND Lasting Battery) OR (Big Screen AND Good Camera) OR …
- (Floats AND High Resolution) OR (Floats AND Small Size) OR (Floats AND Light Weight) OR …
- (Announced Buyback AND Small Cap AND High Idiosyncratic Risk) OR (Small Cap AND Value Stock) OR (Mid Cap AND High Momentum Stock) OR … [Article link]
- (M&A Live Target AND Same Industry as Acquirer) OR (M&A Live Target AND Friendly Acquisition) OR (M&A Live Target AND Cash Deal AND Friendly) OR …

[Article link]

Symbolic AI: ***User Writes*** the Rules/Program



Statistical AI: ***Machine Learns/Writes*** the Rules/Program

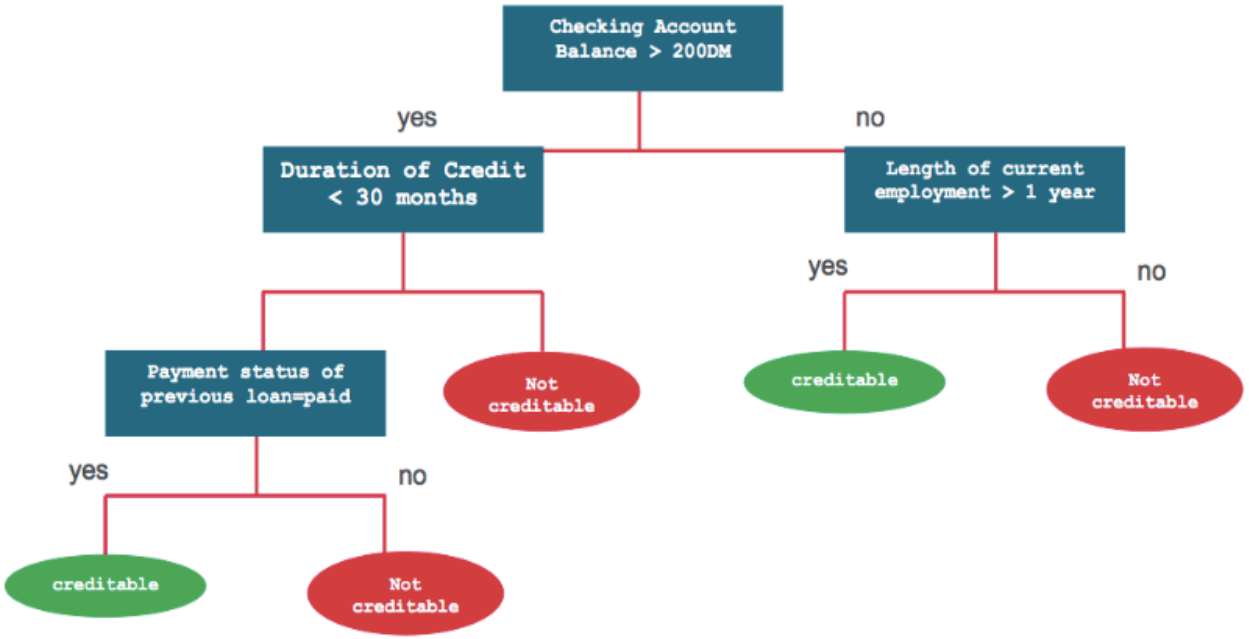


(Adopted from Domingos, 2017)

Rules are Not Enough…
Modern (Statistical) AI

Symbolic AI

- ✓ Explicit “hand written rules” [human designs]
- ✓ Relatively slower update of rules
- ✓ Learning mainly from human experience
- ✓ “Limited” data usage



Statistical AI

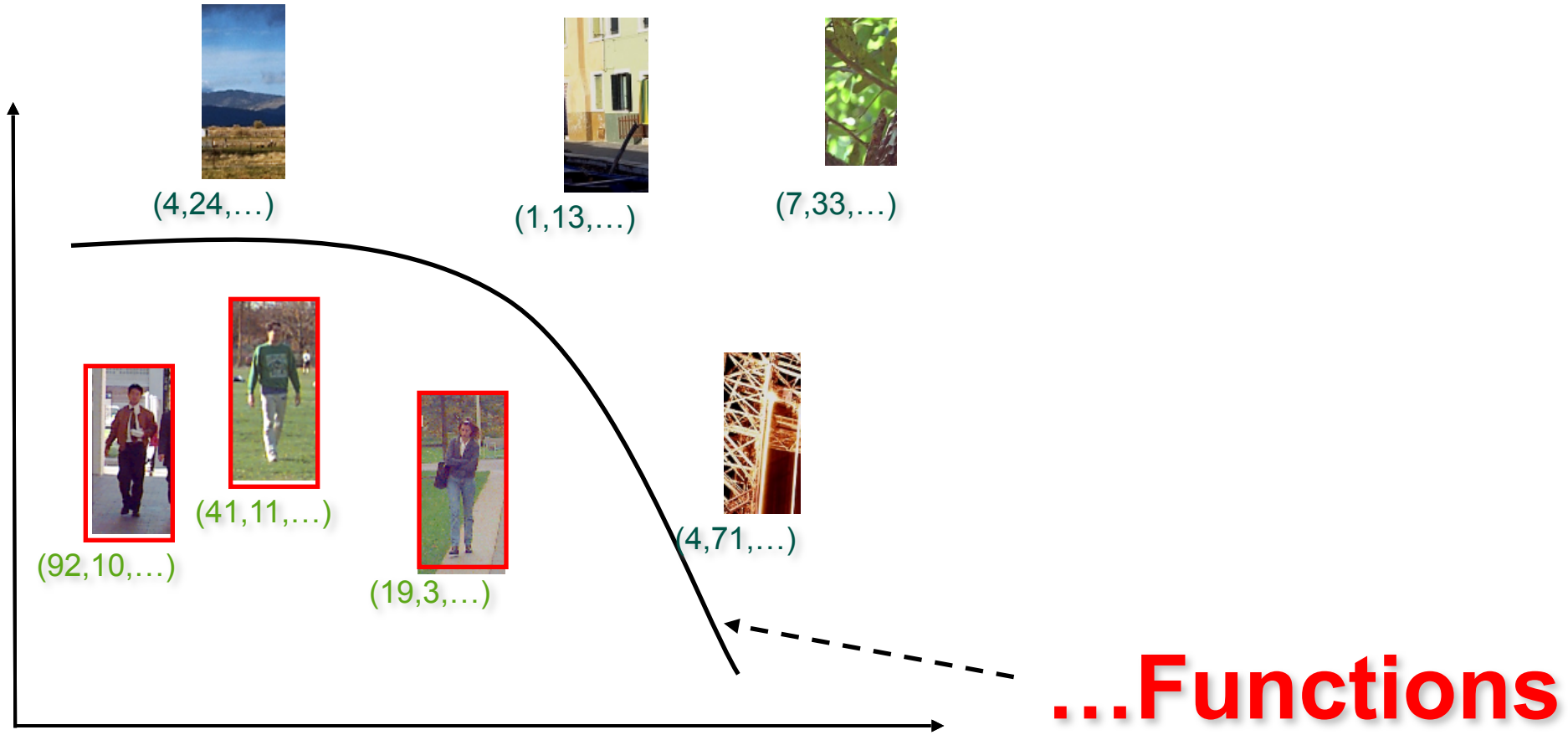
- ✓ Rules + Models from data [not only from human]
- ✓ Rules can evolve fast, e.g. with environment
- ✓ **Learning** mainly from data
- ✓ “Unlimited” data usage

Algorithm 2 (*Multi-Task Feature Learning with Kernels*)

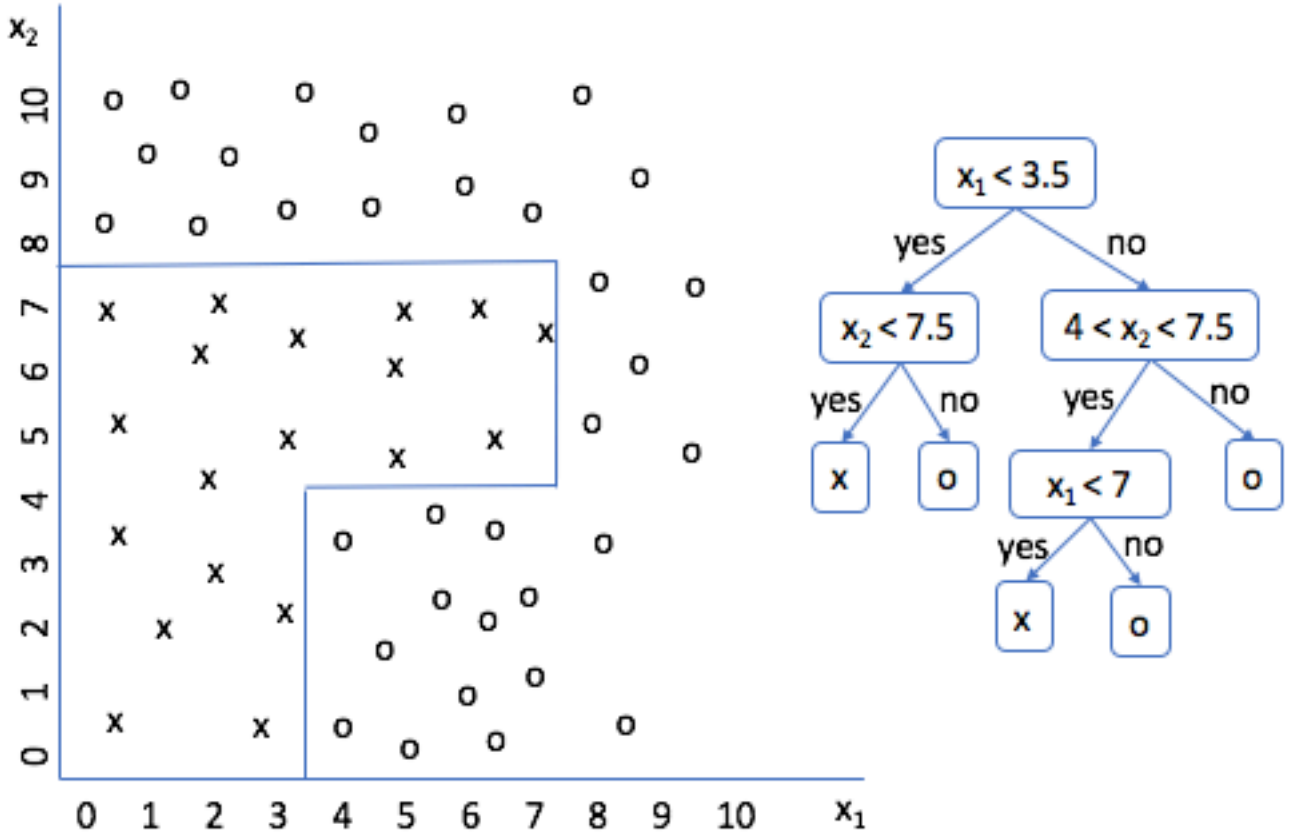
Input: training sets $\{(x_{ti}, y_{ti})\}_{i=1}^{m}, t \in \mathbb{N}_T$
Parameters: regularization parameter γ, tolerances ε, tol
Output: $\delta \times T$ coefficient matrix $B = [b_1, \ldots, b_T]$, indices $\{(t_\nu, i_\nu)\,,\ \nu \in \mathbb{N}_\delta\} \subseteq \mathbb{N}_T \times \mathbb{N}_m$
Initialization: using only the kernel values, find a matrix $R \in \mathbb{R}^{\delta \times \delta}$ and indices $\{(t_\nu, i_\nu)\}$ such that $\{\sum_{\nu=1}^{\delta} \varphi(x_{t_\nu i_\nu}) r_{\nu\mu}\,,\ \mu \in \mathbb{N}_\delta\}$ form an orthogonal basis for the features on the training data
compute the modified inputs $z_{ti} = R^\top \left(K(x_{t_\nu i_\nu}, x_{ti})\right)_{\nu=1}^{\delta}\,, t \in \mathbb{N}_T, i \in \mathbb{N}_m$
set $\Delta = \frac{I}{\delta}$
while $\|\Theta - \Theta_{prev}\| > tol$ **do**
  for $t = 1, \ldots, T$ **do**
    compute $\vartheta_t = \operatorname{argmin}\left\{\sum_{i=1}^{m} L(y_{ti}, \langle \vartheta, z_{ti} \rangle) + \gamma \langle \vartheta, \Delta^{-1} \vartheta \rangle : \vartheta \in \mathbb{R}^\delta\right\}$
  end for
  set $\Delta = \frac{(\Theta\Theta^\top + \varepsilon I)^{\frac{1}{2}}}{\operatorname{trace}(\Theta\Theta^\top + \varepsilon I)^{\frac{1}{2}}}$
end while
return $B = R\Theta$ and $\{(t_\nu, i_\nu), \nu \in \mathbb{N}_\delta\}$

[Article]

Everything for a Computer is Data/Numbers and…



It is mainly (only?) about ***Functions***...



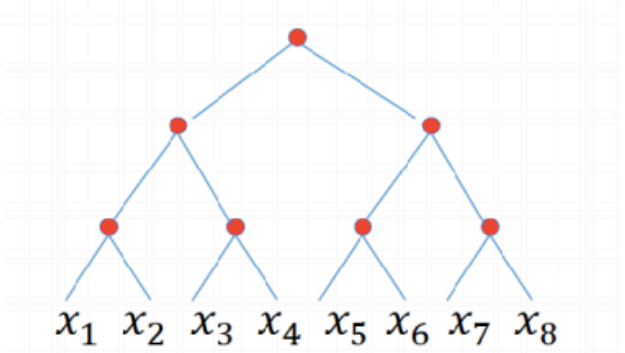
Rules are also Functions

From *"Rules"* to *"Black Box"* Functions

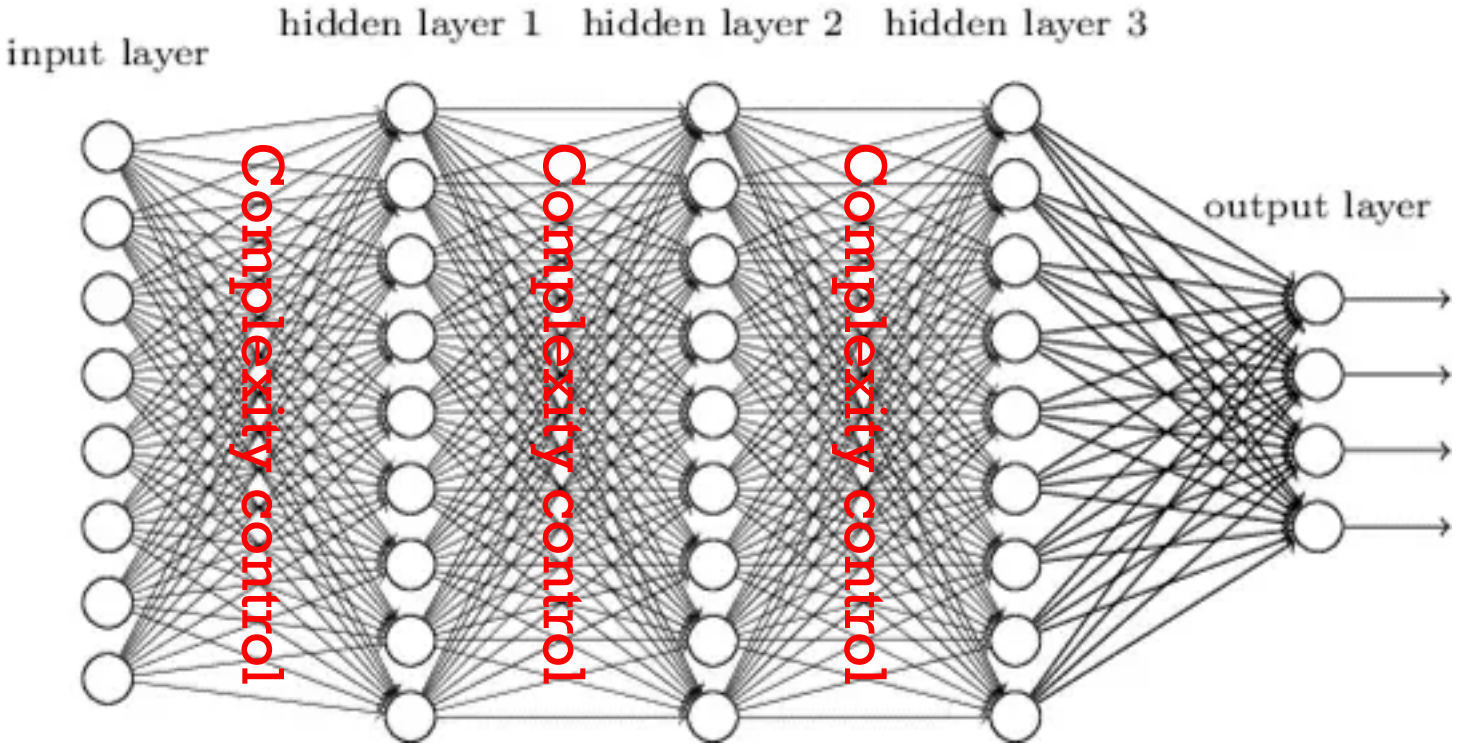
Most Machine Learning methods "learn" (find) functions that cannot be expressed, and explained, with simple rules.

[the learned functions are often kind of "infinite rules", with "infinite number of parameters" – some may say like the "infinite" connections between neurons developed/learned due e.g. to neural plasticity]

$$f(x_1,x_2,\ldots,x_8) = g_3(g_{21}(g_{11}(x_1,x_2),g_{12}(x_3,x_4))g_{22}(g_{11}(x_5,x_6),g_{12}(x_7,x_8)))$$

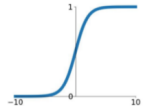


Deep neural network

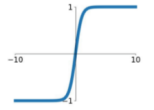


Activation Functions

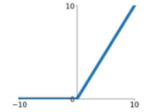
Sigmoid
$\sigma(x) = \frac{1}{1+e^{-x}}$



tanh
$\tanh(x)$



ReLU
$\max(0, x)$



The "*New Physics of Intelligence*"?

"Why is it that the simple, abstract language of mathematics can accurately capture so much of our infinitely complex ~~world~~ [human intelligence]?"

Eugene Wigner, Physics Nobel laureate, 1959
"*The Unreasonable Effectiveness of Mathematics in the Natural Sciences*"

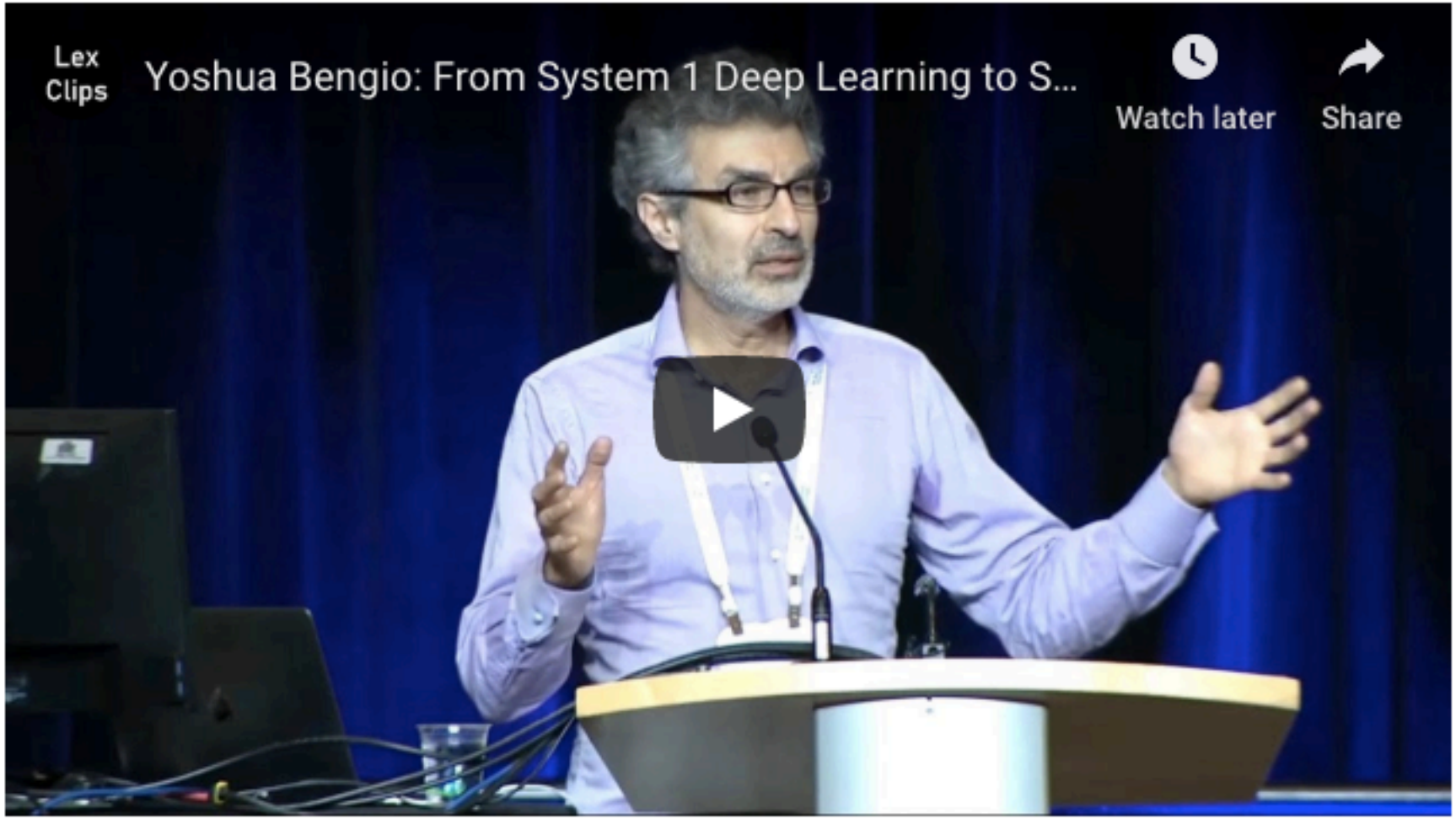
Explainable AI?

The “AI Polanyi’s Paradox”?

Machines, like humans, know more than they can tell

Yoshua Bengio: From System 1 Deep Learning to System 2 Deep Learning | NeurIPS 2019

DECEMBER 12, 2019



DEEP LEARNING FOR SYMBOLIC MATHEMATICS

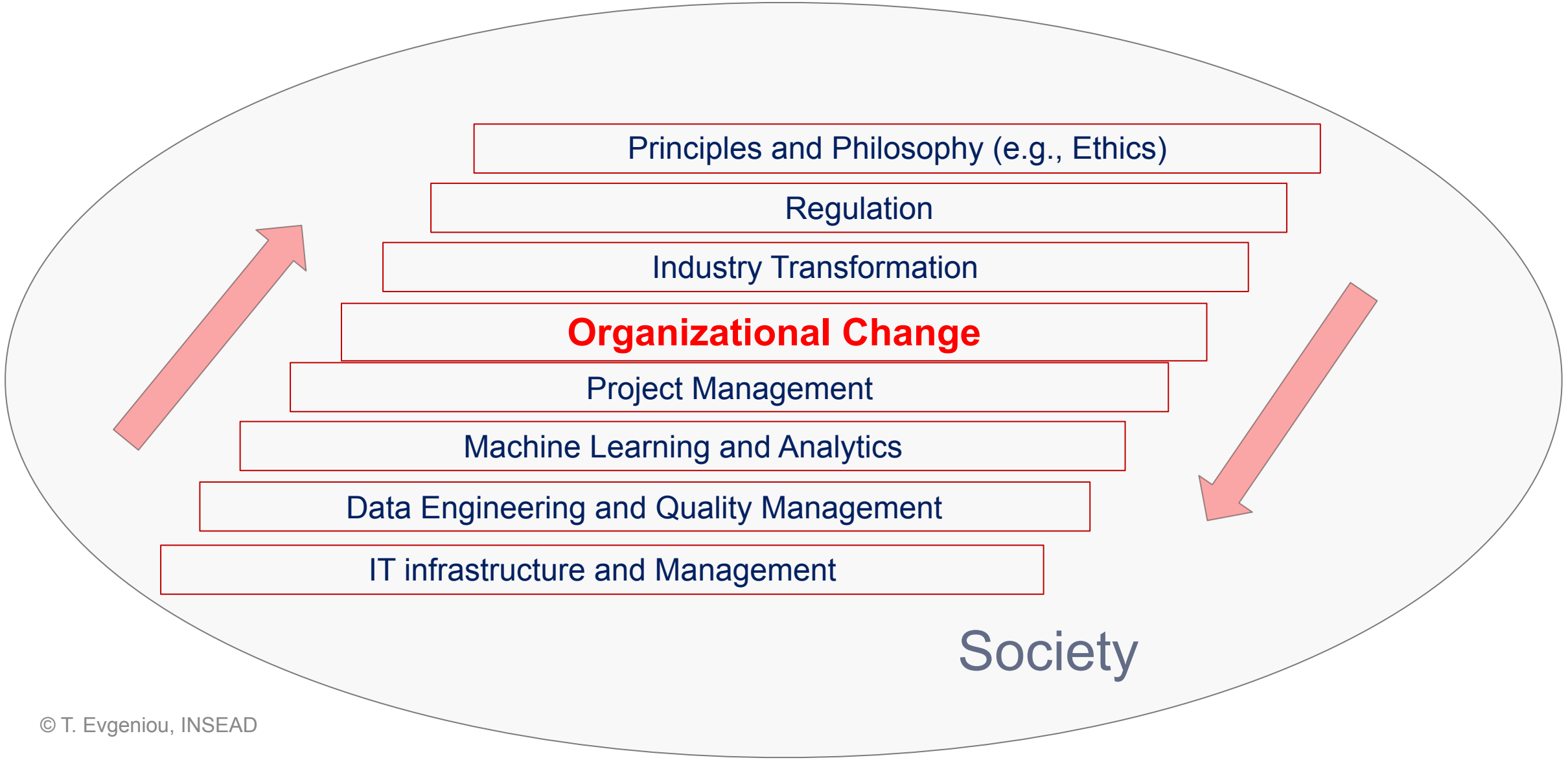
Guillaume Lample*
Facebook AI Research
glample@fb.com

François Charton*
Facebook AI Research
fcharton@fb.com

We propose a syntax for representing mathematical problems, and methods for generating large datasets that can be used to train sequence-to-sequence models. We achieve results that outperform commercial Computer Algebra Systems such as Matlab or Mathematica.

On all tasks, we observe that our model significantly outperforms Mathematica. On function integration, our model obtains close to 100% accuracy, while Mathematica barely reaches 85%. On

A Key Message:
AI requires a *Holistic Approach*



"[This] isn't a software package; it's a way of doing business"

Quote from an executive (1998 - for ERPs)

"The dominant issue in computer technology will be the ability to implement human behavior change."

Warren McFarlan, 1968

Research Questions:

- Micro+Macro adoption factors?
- Implications for AI Regulation?

npj | Digital Medicine

(Nature Digital Medicine, Forthcoming)

Regulating artificial intelligence/machine learning-based software as a medical device: the need for a system view

Sara Gerke, Boris Babic, Theodoros Evgeniou & I. Glenn Cohen*

AI Opportunities: The Standard “Buckets”, plus Humans+Machines

1. AI for Products/Services (medical diagnosis, energy, IoT, autonomous veh., etc)

2. AI for Business Process Optimization (customer relations, HR, R&D, Prev. Maint., etc)

3. **AI for People (Decision Enhancement and Job Augmentation)**

Harvard Business Review

(Forthcoming)

Adopt AI as a Coach to Enhance your Company's most Frequent Decisions

Boris Babic, JD, PhD; Daniel L. Chen, JD, PhD;
Theodoros Evgeniou, PhD; Anne-Laure Fayard, PhD

INSEAD

Step 1

AI - Personal Assistant

AI is introduced without requiring any changes in people's work. It works as an autocomplete or recommender system which helps people go faster about their jobs

Step 2:

AI - Personal Monitor

AI notices if you make a choice that is inconsistent with previous choices and lets you know about the inconsistency so that you can correct your decision if that was not done on purpose - you might be tired or got distracted.

Step 3:

AI - Personal Coach

AI provides training enhancement and a feedback loop that allows users to look at their own performance and reflect on variations and errors. It can also use a case-based training system to help users understanding better their decision patterns and practices.

Step 4:

Human & Machine Collective Intelligence

As the AI becomes better through its interactions with different users and their feedback at each level, and as expert users are analyzed, a community of experts (humans and machines) emerges. Individuals can refer to this community and compare their choices to the choices of different experts.

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Automating the B2B Salesperson Pricing Decisions: Can Machines Replace Humans and When?

65 Pages • Posted: 6 May 2019

Yael Karlinsky-Shichor
Northeastern University - D'Amore-McKim School of Business

Oded Netzer
Columbia Business School - Marketing

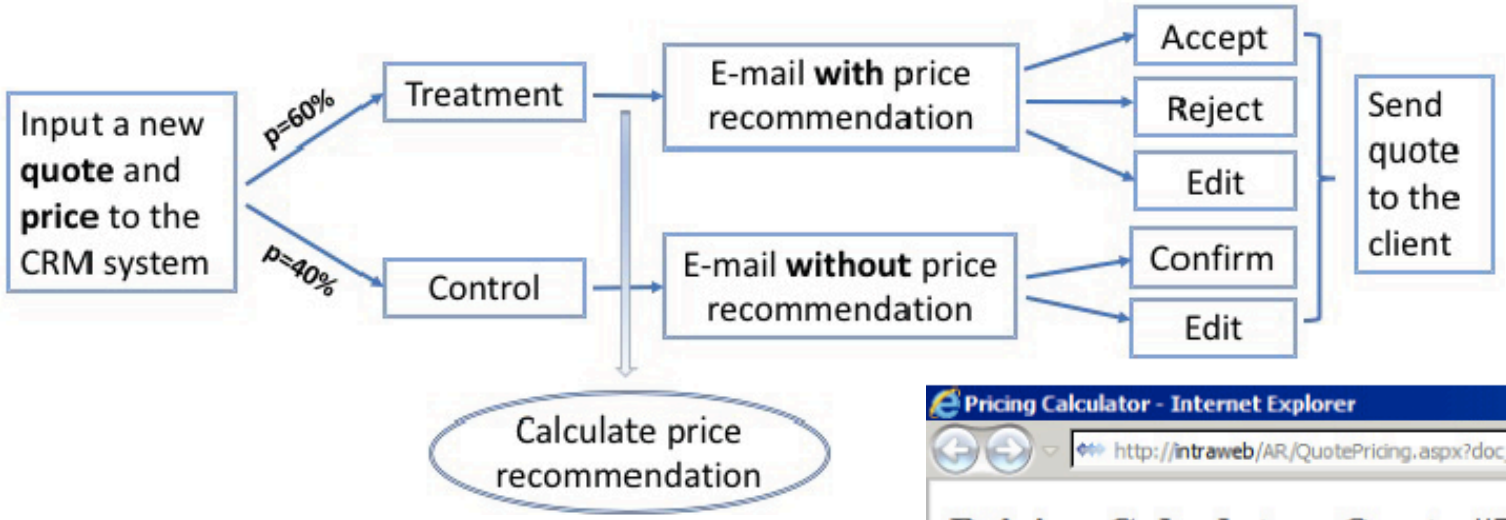

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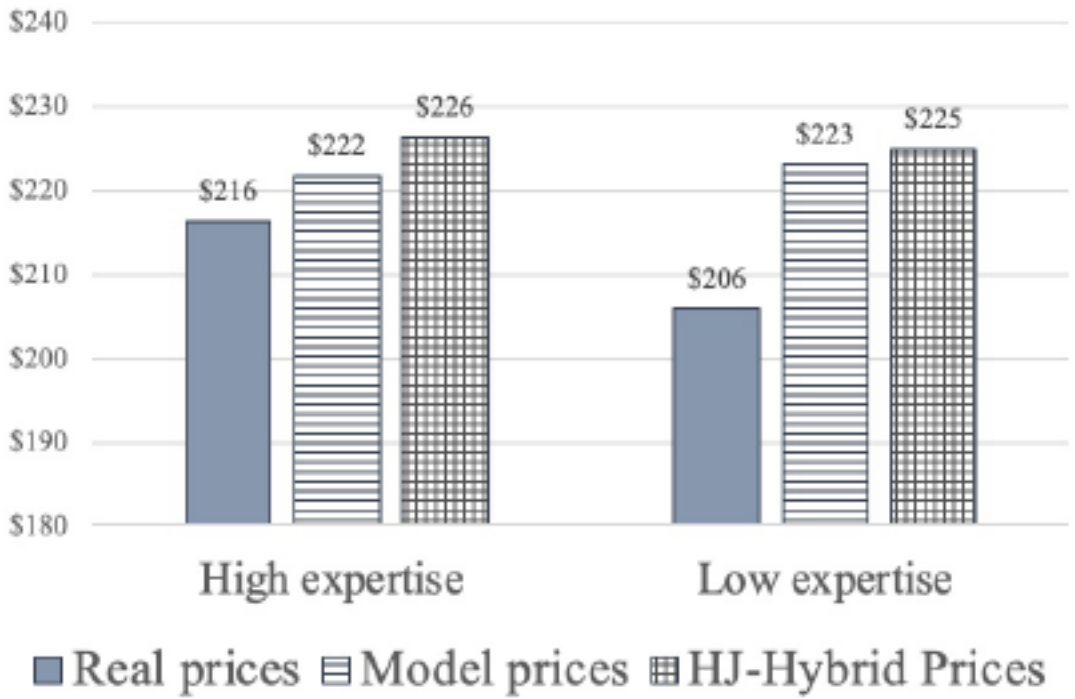
Figure 4: Expected Profits by Salesperson Expertise



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Who is Tested for Heart Attack and Who Should Be: Predicting Patient Risk and Physician Error

NBER Working Paper No. w26168

49 Pages • Posted: 20 Aug 2019 • Last revised: 23 Aug 2019

Sendhil Mullainathan
University of Chicago

Ziad Obermeyer
University of California, Berkeley

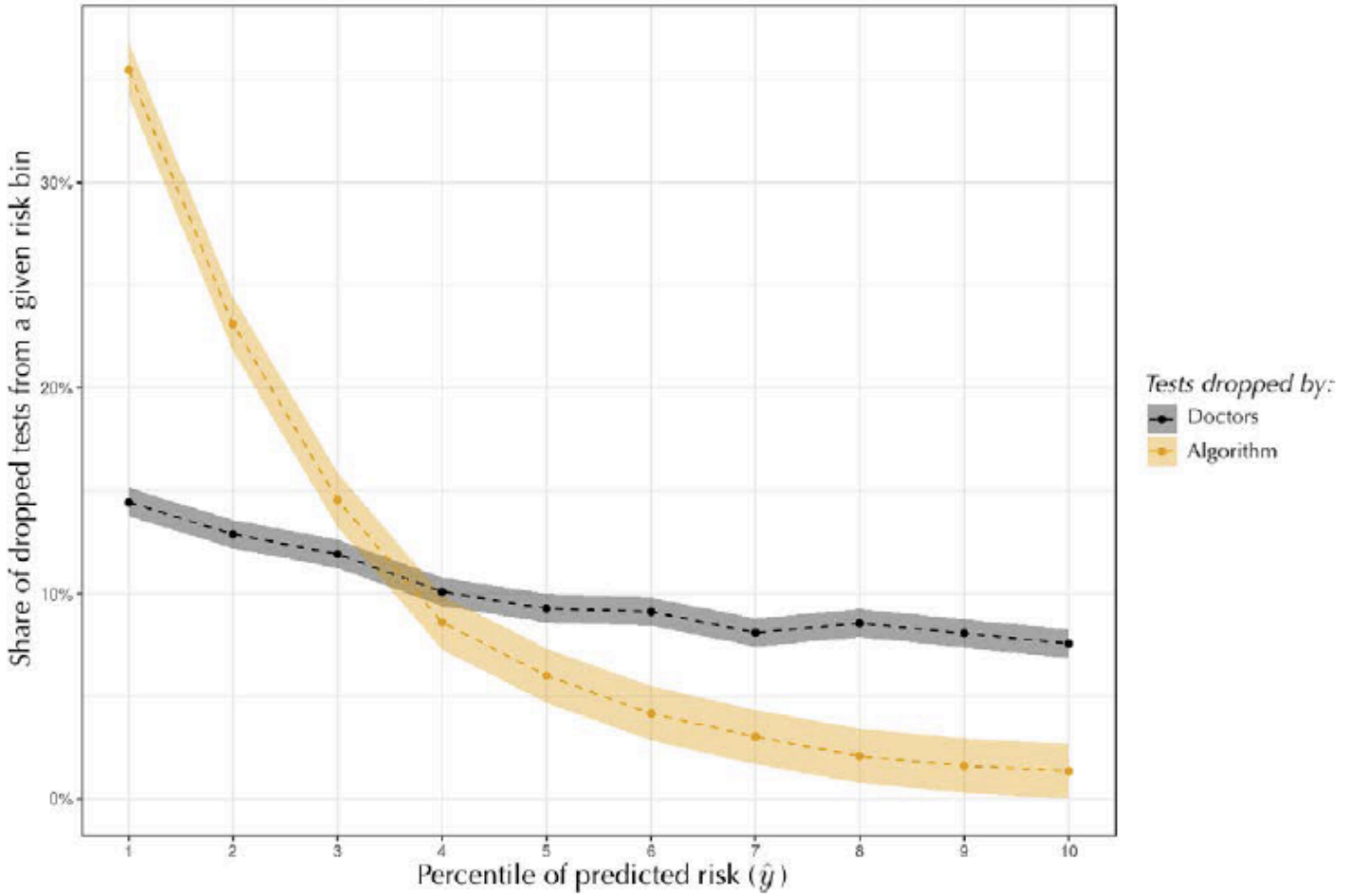

Figure 9: Risk distribution of marginal patients: Difference in testing rates, weekday vs. weekend, by distribution of predicted yield $\hat{y}_i$, comparing observed doctor testing decisions vs. simulated algorithm 'decisions' (conditional on geography and year).

Harvard Business Review

(Forthcoming)

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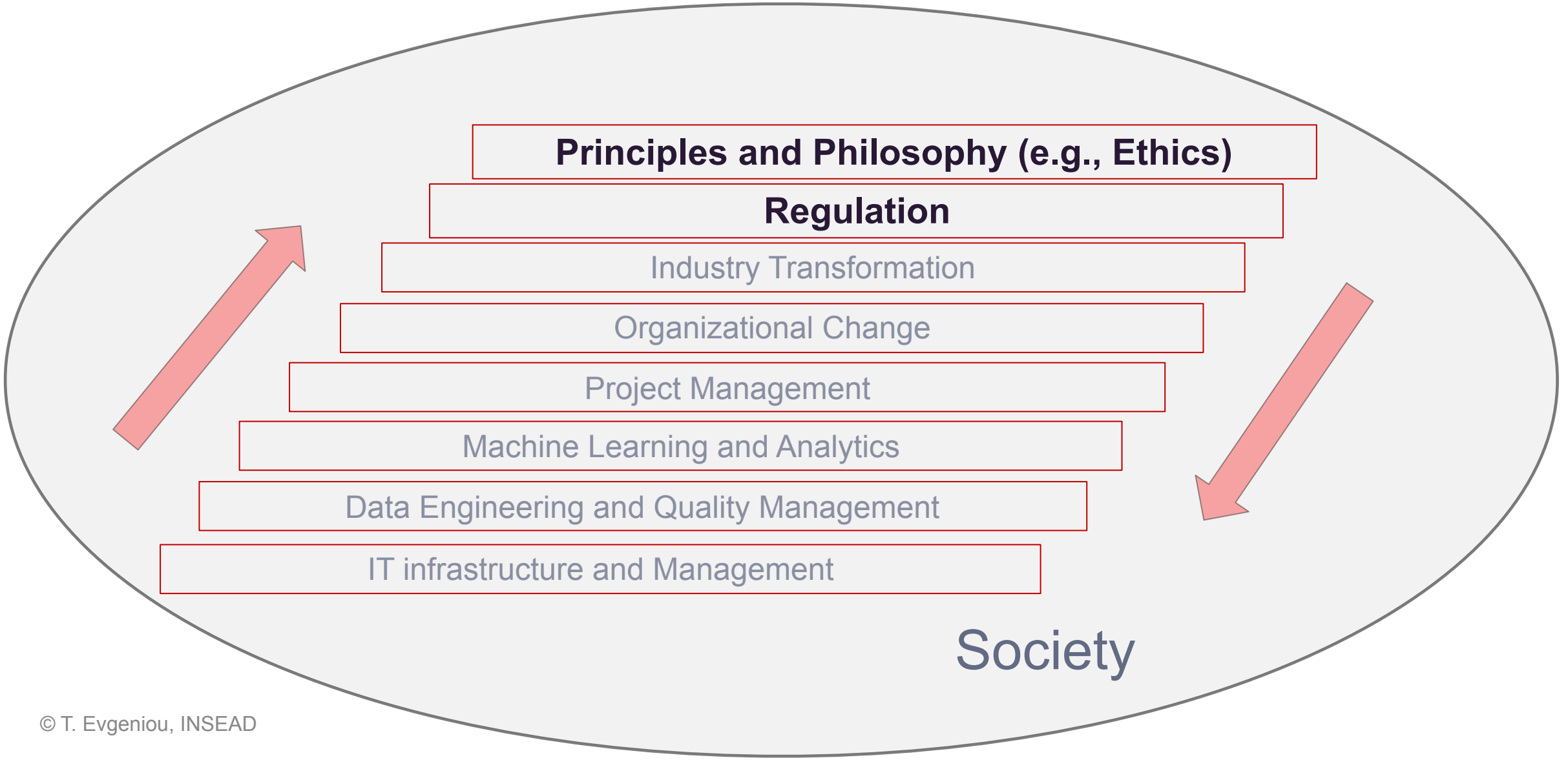
Research Questions

1. When can “judgmental bootstrapping” be used to enhance decisions? Why or why not? How?

1. What is the best process to combine “humans + machines” (in each case)? *[Kasparov’s Law]*

2. How to combine *many* “humans” and *many* “human models”? What can we learn from these (e.g., disagreements and biases, consistency and tail events, etc)?

Key Message:
AI requires a *Holistic Approach*



AI and Regulation: A Booming Research Area…

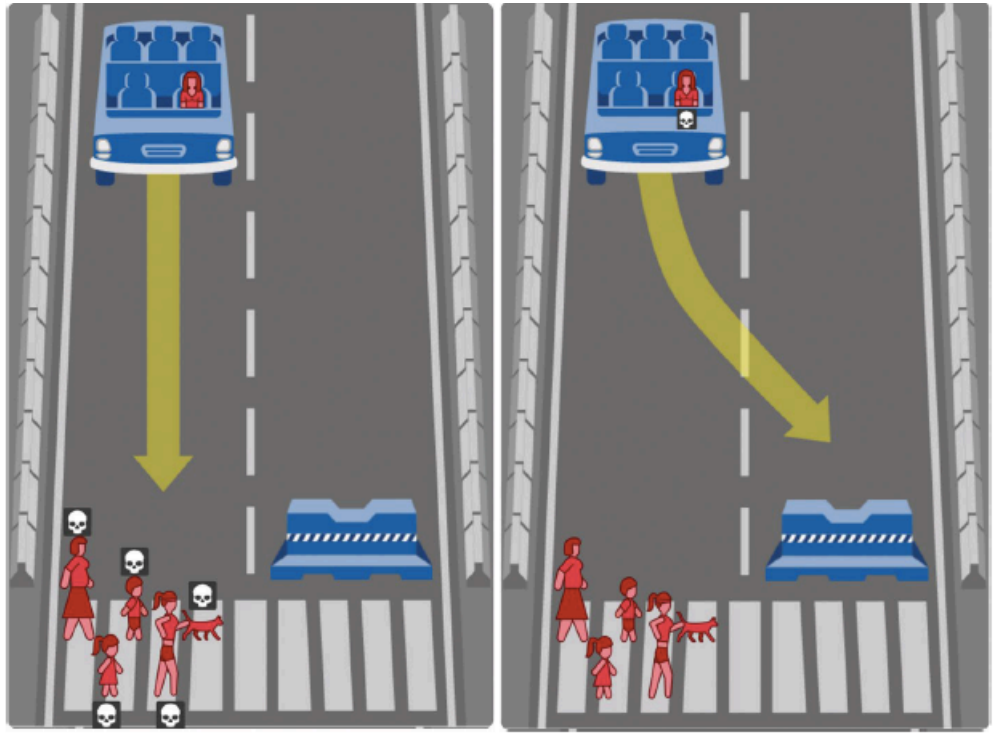
INSEAD

comment

Psychological roadblocks to the adoption of self-driving vehicles

Self-driving cars offer a bright future, but only if the public can overcome the psychological challenges that stand in the way of widespread adoption. We discuss three: ethical dilemmas, overreactions to accidents, and the opacity of the cars' decision-making algorithms — and propose steps towards addressing them.

Azim Shariff, Jean-François Bonnefon and Iyad Rahwan



Regulating Black-Box Medicine

W. Nicholson Price II
University of Michigan Law School, wnp@umich.edu

REVIEW

https://doi.org/10.1038/s41586-019-1138-y

Machine behaviour

Iyad Rahwan[1,2,3,34*], Manuel Cebrian[1,34], Nick Obradovich[1,34], Josh Bongard[4], Jean-François Bonnefon[5], Cynthia Breazeal[1], Jacob W. Crandall[6], Nicholas A. Christakis[7,8,9,10], Iain D. Couzin[11,12,13], Matthew O. Jackson[14,15,16], Nicholas R. Jennings[17,18], Ece Kamar[19], Isabel M. Kloumann[20], Hugo Larochelle[21], David Lazer[22,23,24], Richard McElreath[25,26], Alan Mislove[27], David C. Parkes[28,29], Alex 'Sandy' Pentland[1], Margaret E. Roberts[30], Azim Shariff[31], Joshua B. Tenenbaum[32] & Michael Wellman[33]

Machines powered by artificial intelligence increasingly mediate our social, cultural, economic and political interactions. Understanding the behaviour of artificial intelligence systems is essential to our ability to control their actions, reap their benefits and minimize their harms. Here we argue that this necessitates a broad scientific research agenda to study machine behaviour that incorporates and expands upon the discipline of computer science and includes insights from across the sciences. We first outline a set of questions that are fundamental to this emerging field and then explore the technical, legal and institutional constraints on the study of machine behaviour.

AI Auditing and Certification

The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems

The Ethics Certification Program for Autonomous and Intelligent Systems

ECPAIS – Objectives

I. Develop an Ethics Certification Program for;
   i. Transparency
   ii. Accountability
   iii. Algorithmic Bias

II. Efficiently and in Response to Stakeholder's needs

IEEE

What happens when your AI/ML enhanced products or services *make decisions* that cause harm or injury?

The American Bar Association anticipates a number of different new types of lawsuits due to AI; are executives and boards ready for these new risks?

Managing New AI Risks: Lessons From the Medical World

Harvard Business Review

(Forthcoming)

By
Boris Babic, JD, PhD; I. Glenn Cohen, JD; Theodoros Evgeniou, PhD; Sara Gerke, Dipl.-Jur. Univ., M.A. Medical Ethics and Law
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Research Questions: How to regulate AI?

Science AAAS

Science 06 Dec 2019:

Article

INSIGHTS

POLICY FORUM

BIOMEDICAL TECHNOLOGY REGULATION

Algorithms on regulatory lockdown in medicine

Regulation should prioritize continuous risk monitoring

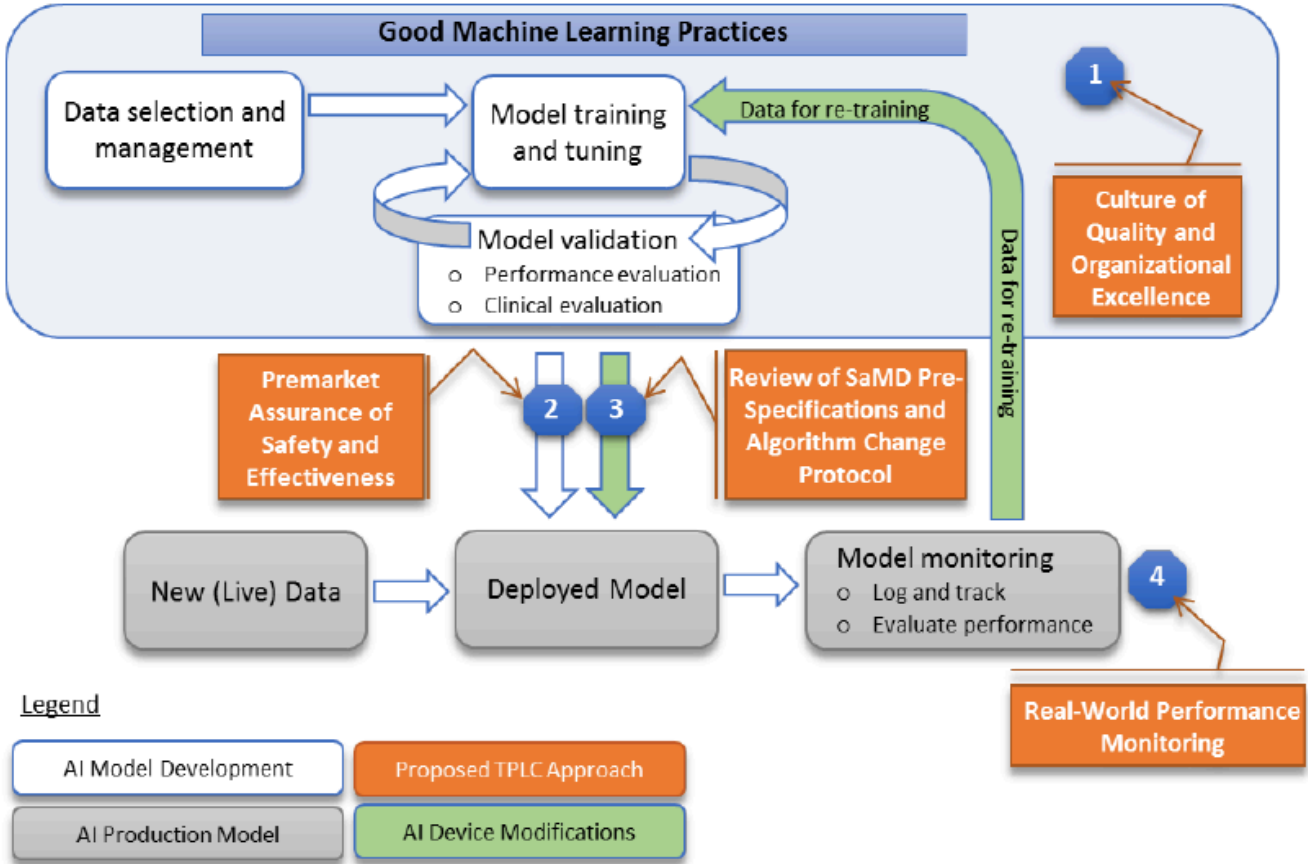
By **Boris Babic[1], Sara Gerke[2], Theodoros Evgeniou[1], I. Glenn Cohen[3]**

s use of artificial intelligence and ma-

much the way a medical resident learns on the job. But this poses a difficult regulatory design challenge. Consider two polar approaches to the update problem:

Some Starting Points

1. Think like a (good) regulator and certify AI first
2. Total Product Lifecycle Management
3. Audit AI and Monitor continuously
4. Develop AI principles and practices for the business



From Principles to Practice: More Research Directions?

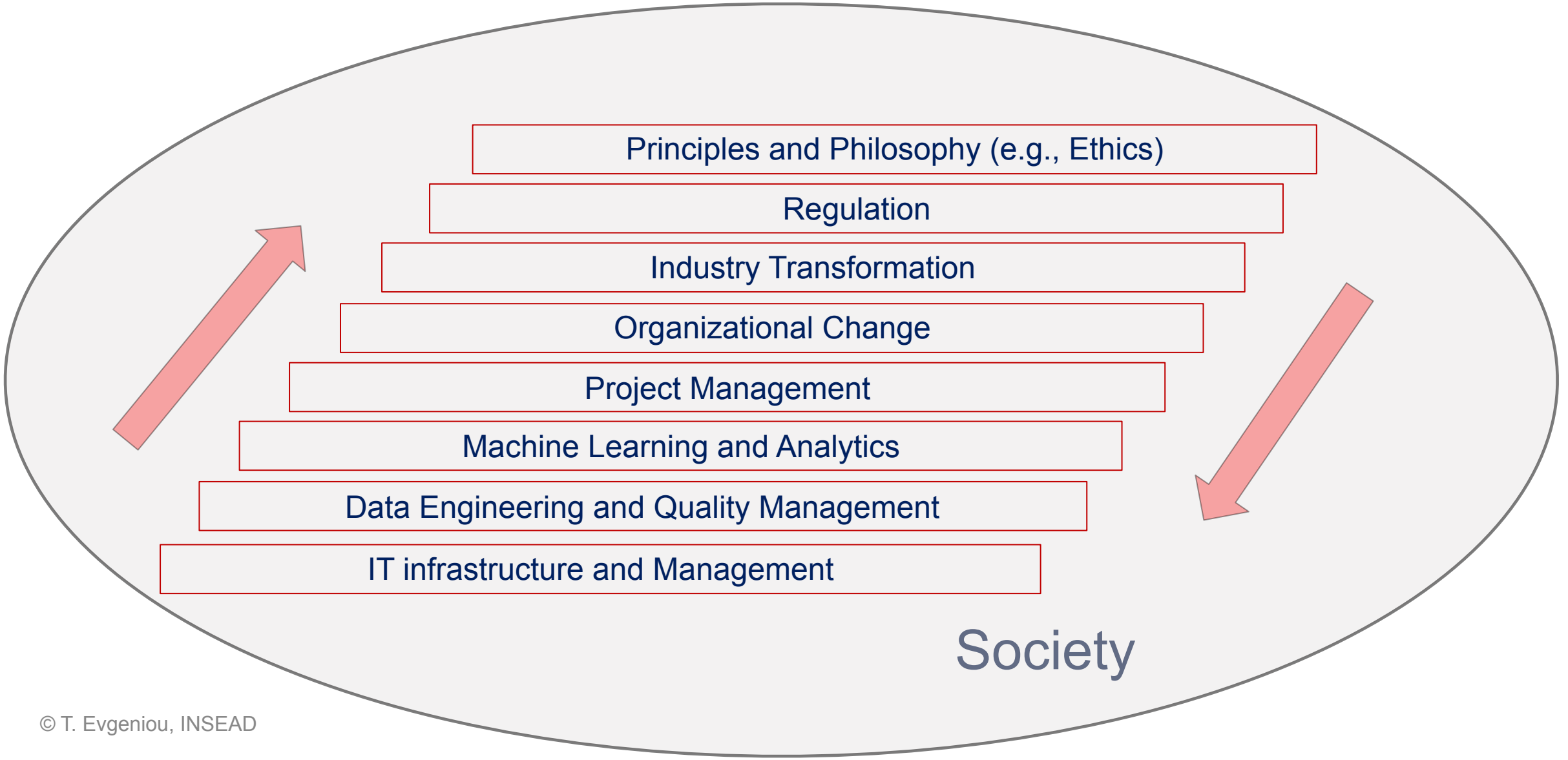
AI That Reflects American Values

We don't have to decide between freedom and technology.

Jan 7, 2020

1. **Public trust in AI.** The government must promote reliable, robust, and trustworthy AI applications.
2. **Public participation.** The public should have a chance to provide feedback in all stages of the rule-making process.
3. **Scientific integrity and information quality.** Policy decisions should be based on science.
4. **Risk assessment and management.** Agencies should decide which risks are and aren't acceptable.
5. **Benefits and costs.** Agencies should weigh the societal impacts of all proposed regulations.
6. **Flexibility.** Any approach should be able to adapt to rapid changes and updates to AI applications.
7. **Fairness and nondiscrimination.** Agencies should make sure AI systems don't discriminate illegally.
8. **Disclosure and transparency.** The public will trust AI only if it knows when and how it is being used.
9. **Safety and security.** Agencies should keep all data used by AI systems safe and secure.
10. **Interagency coordination.** Agencies should talk to one another to be consistent and predictable in AI-related policies.

A Key Message:
AI requires a *Holistic Approach*



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