Prediction Machines:
The Simple Economics of Artificial Intelligence

Deep Learning and Reinforcement Learning Summer School
August 2, 2018
The Rotman School, Toronto

Ajay Agrawal
University of Toronto and NBER

Based on research with Joshua Gans and Avi Goldfarb

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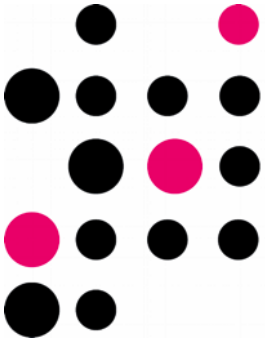
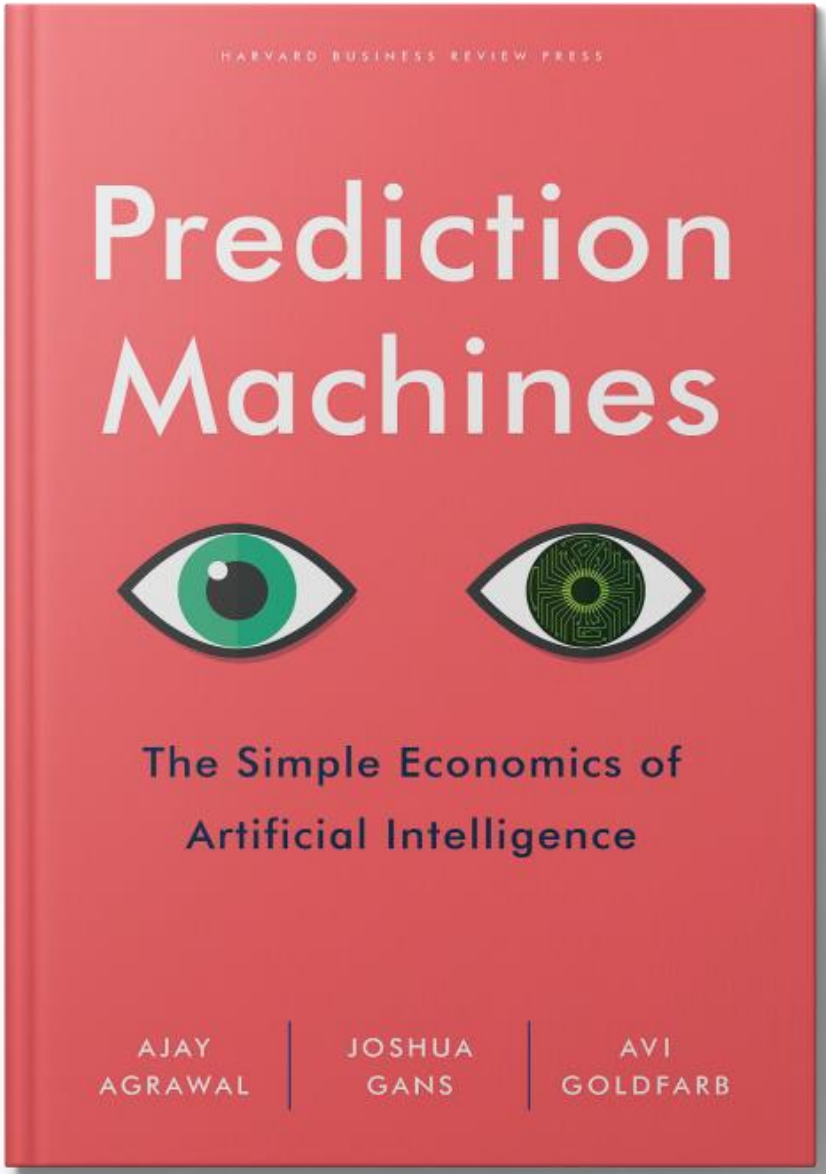


CREATIVE DESTRUCTION LAB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The Simple Economics of Artificial Intelligence
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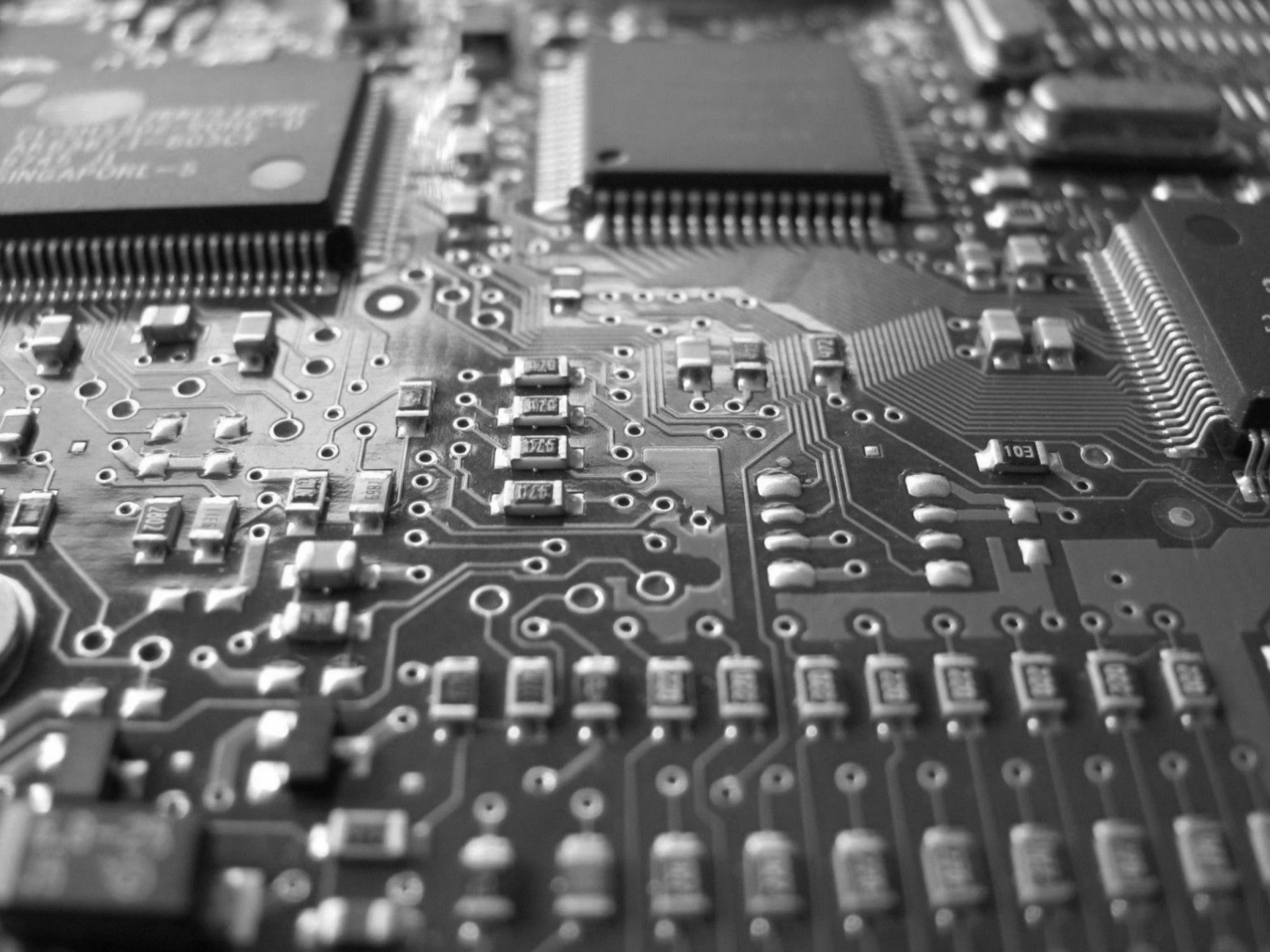
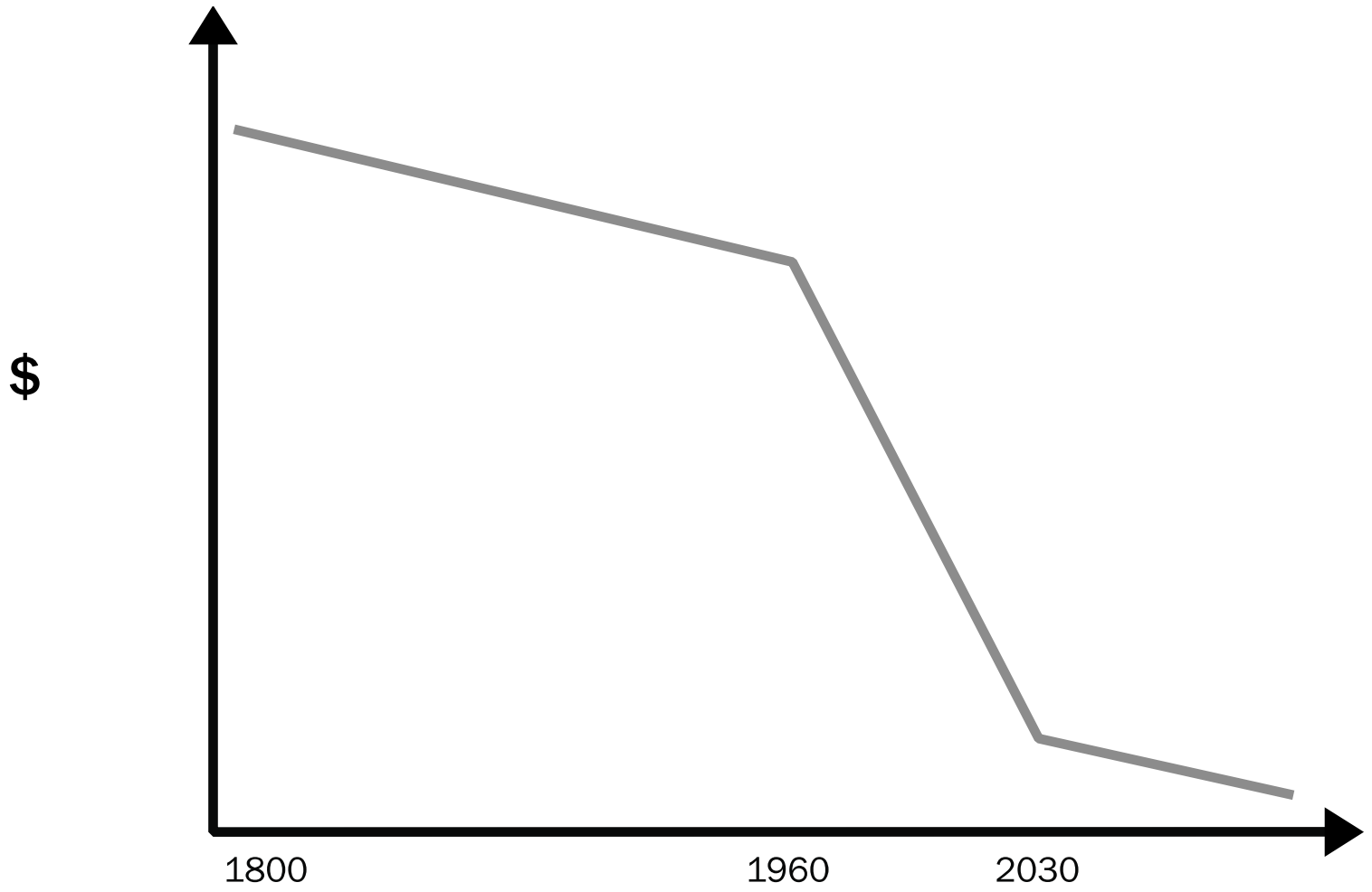
1995?

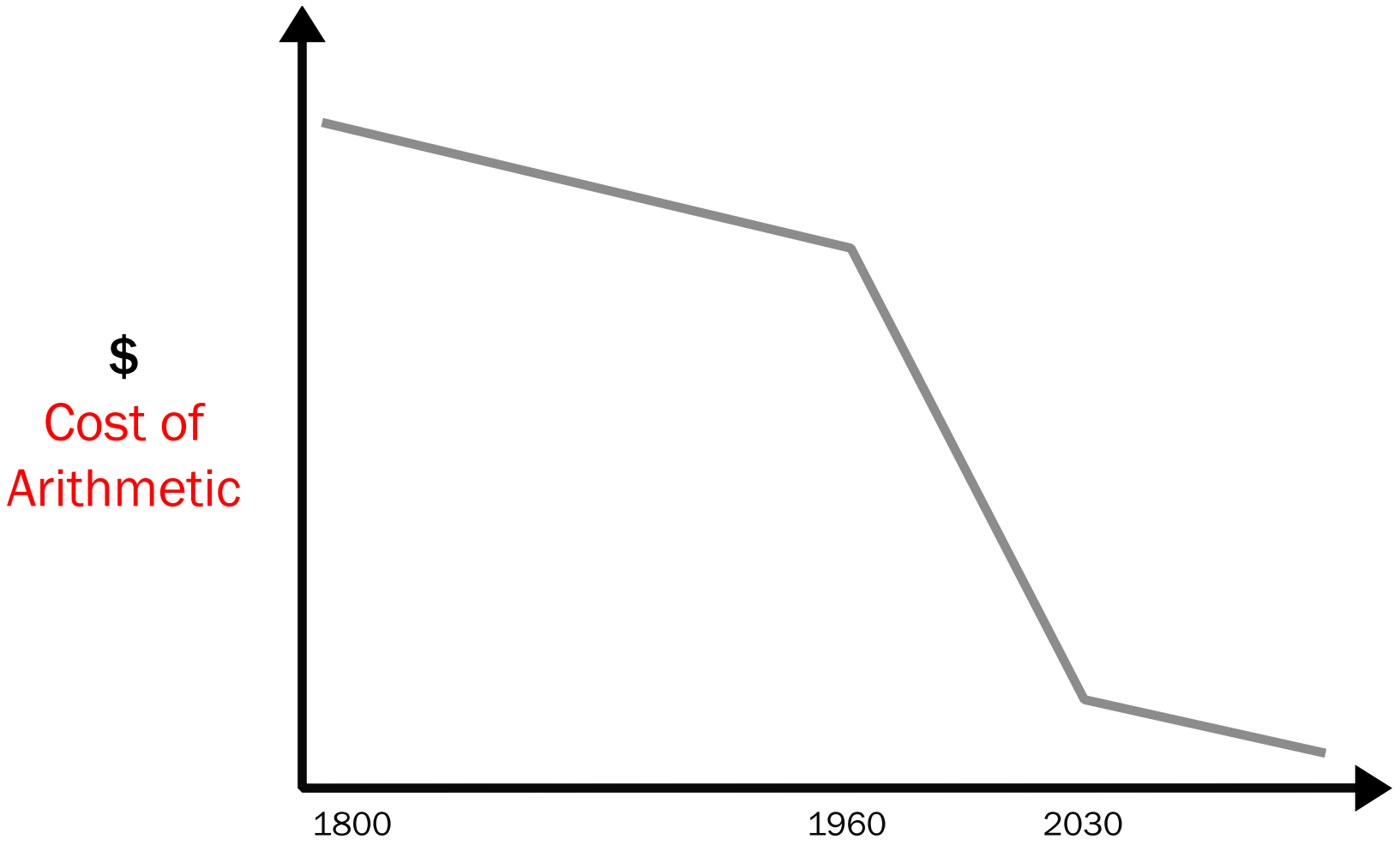

New Economy



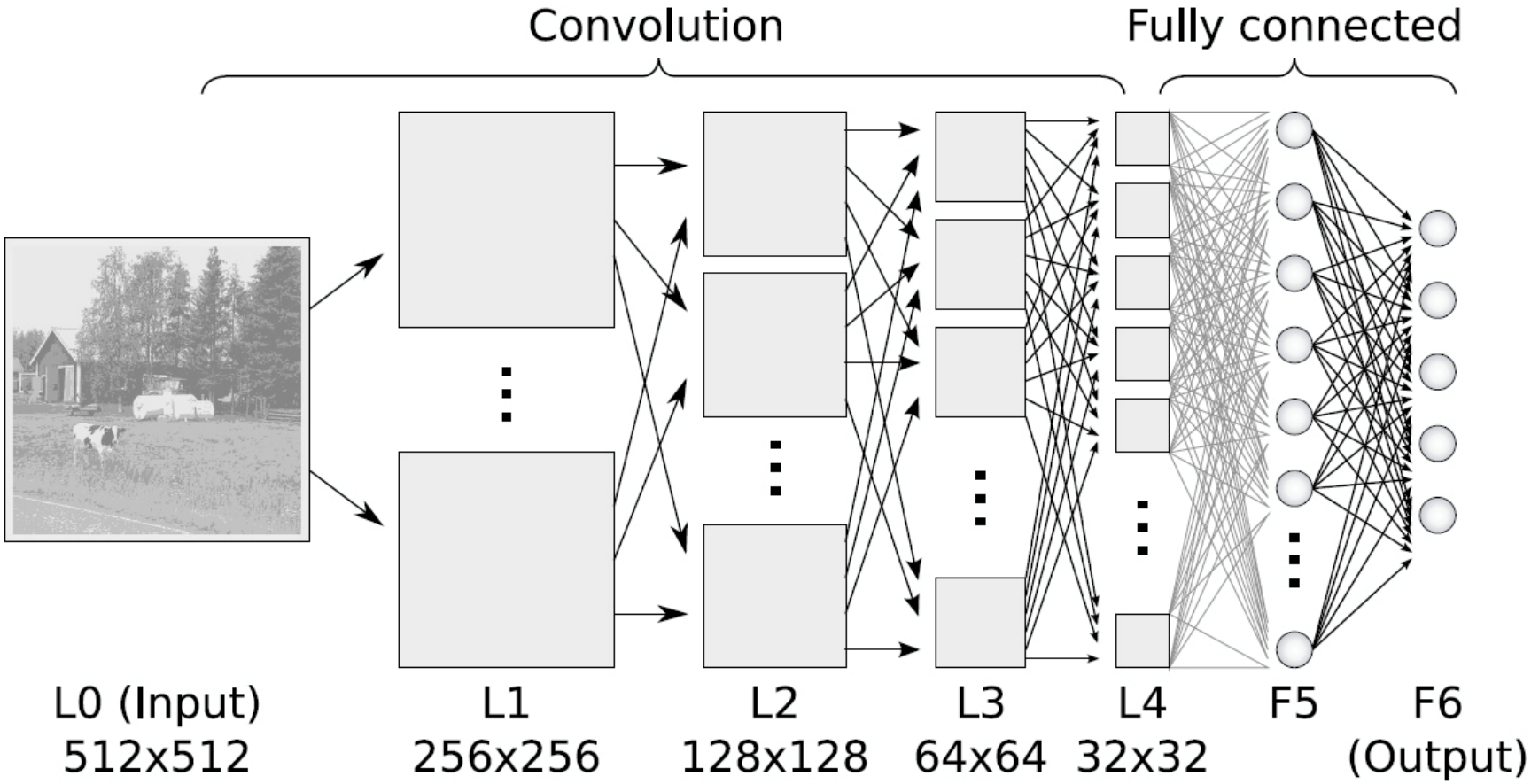
Semiconductors



Semiconductors

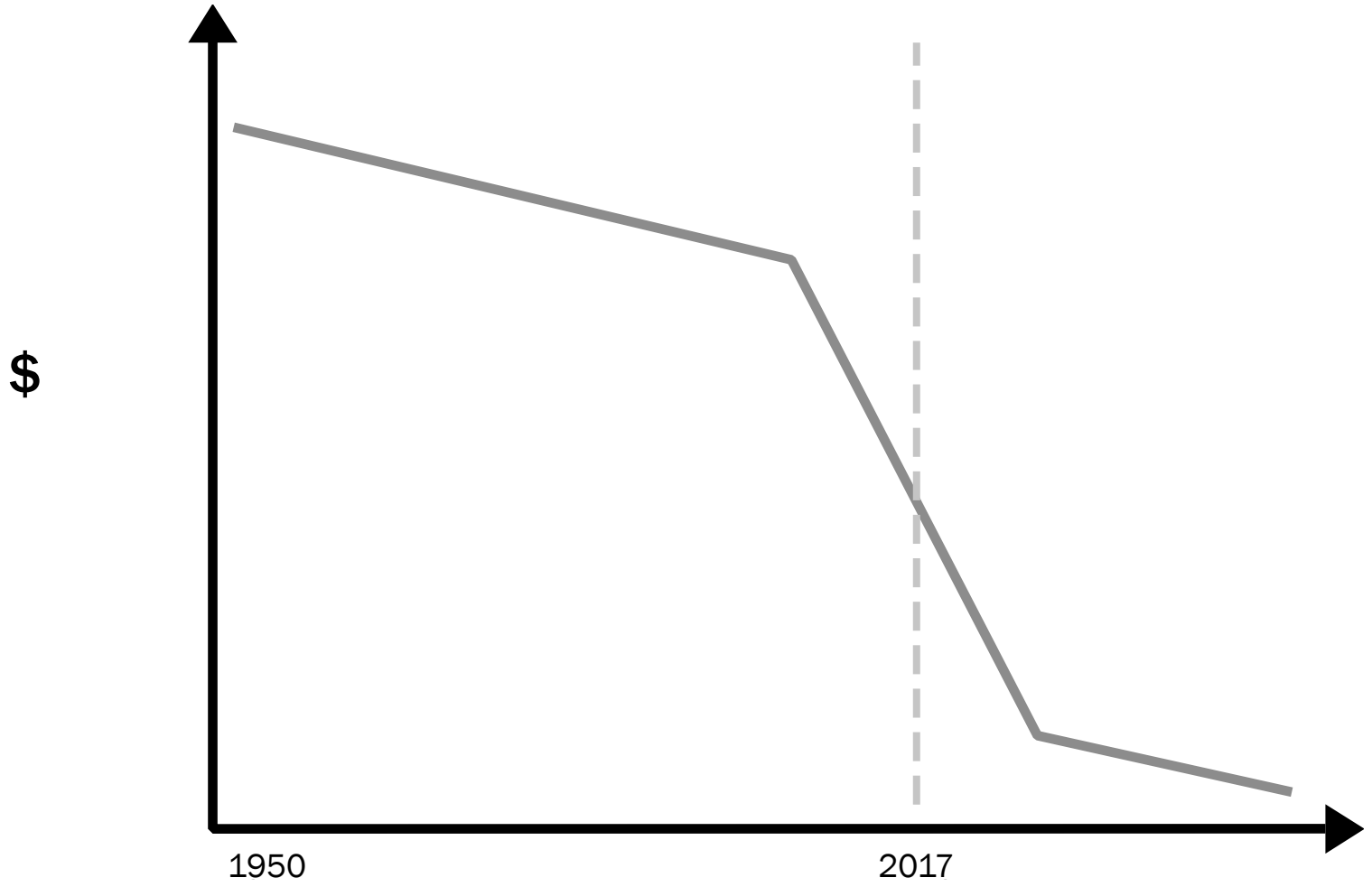


Expanding Range of Use as Input

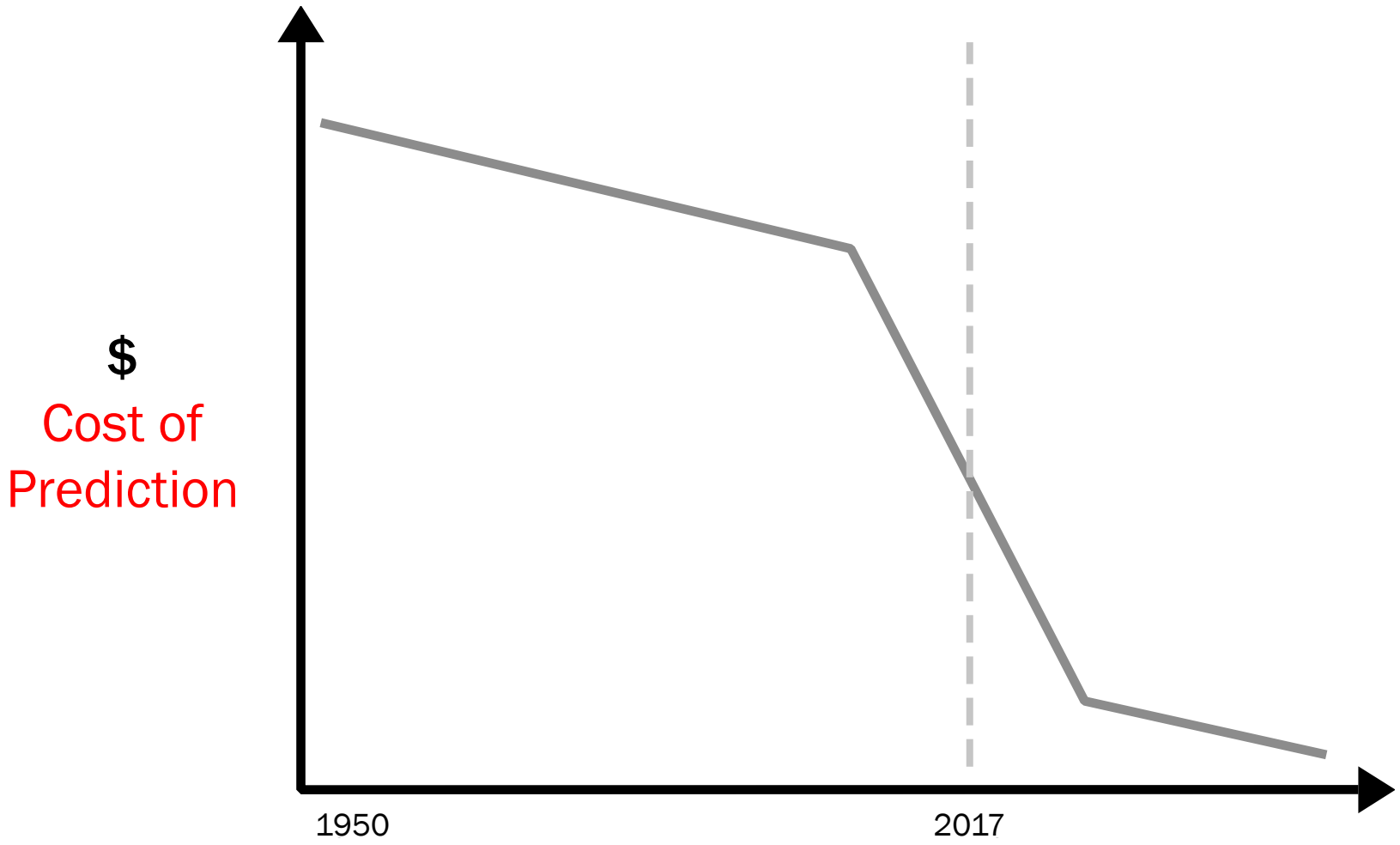


Source: https://www.ais.uni-bonn.de/deep_learning/

Artificial Intelligence



Artificial Intelligence

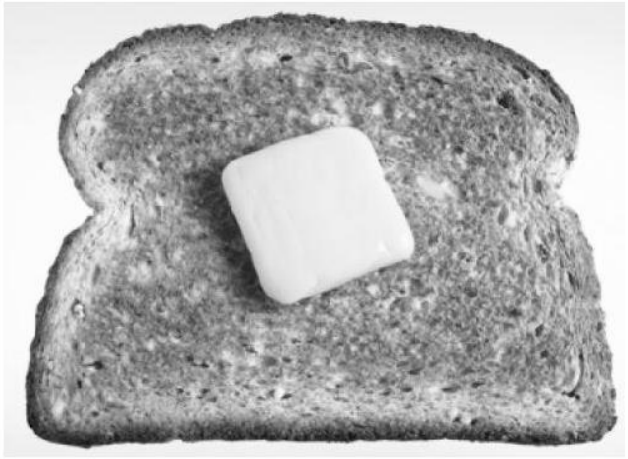


PREDICTION:
USING INFORMATION THAT YOU DO HAVE TO GENERATE INFORMATION THAT YOU DON'T HAVE

Expanding Range of Use as Input

Expanding Range of Use as Input

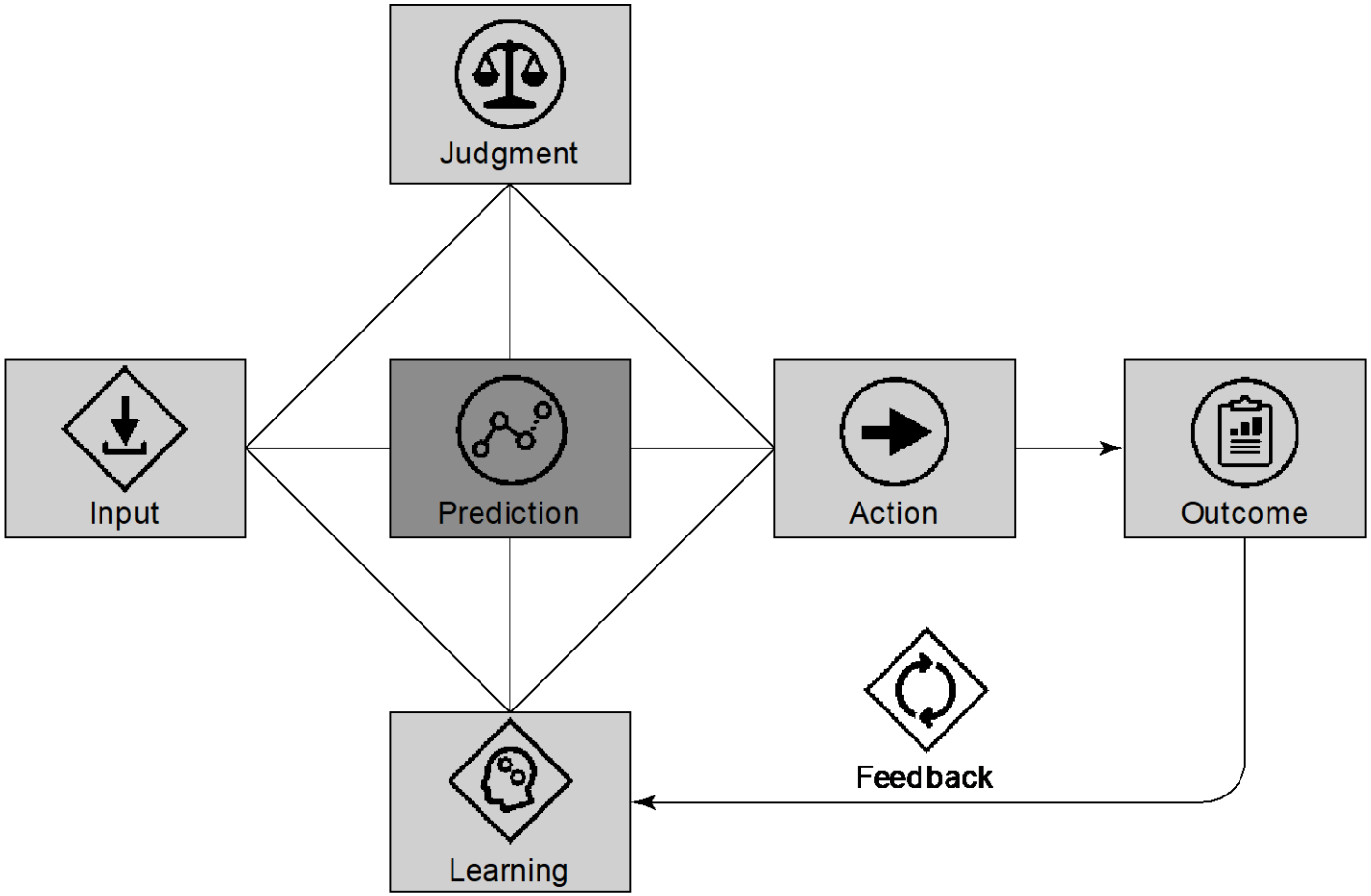
Complements



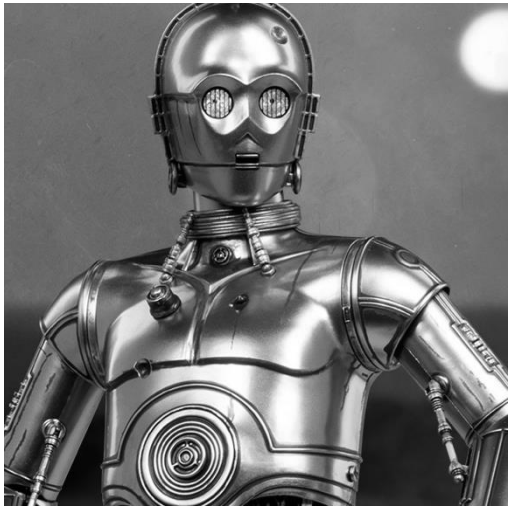
Substitutes

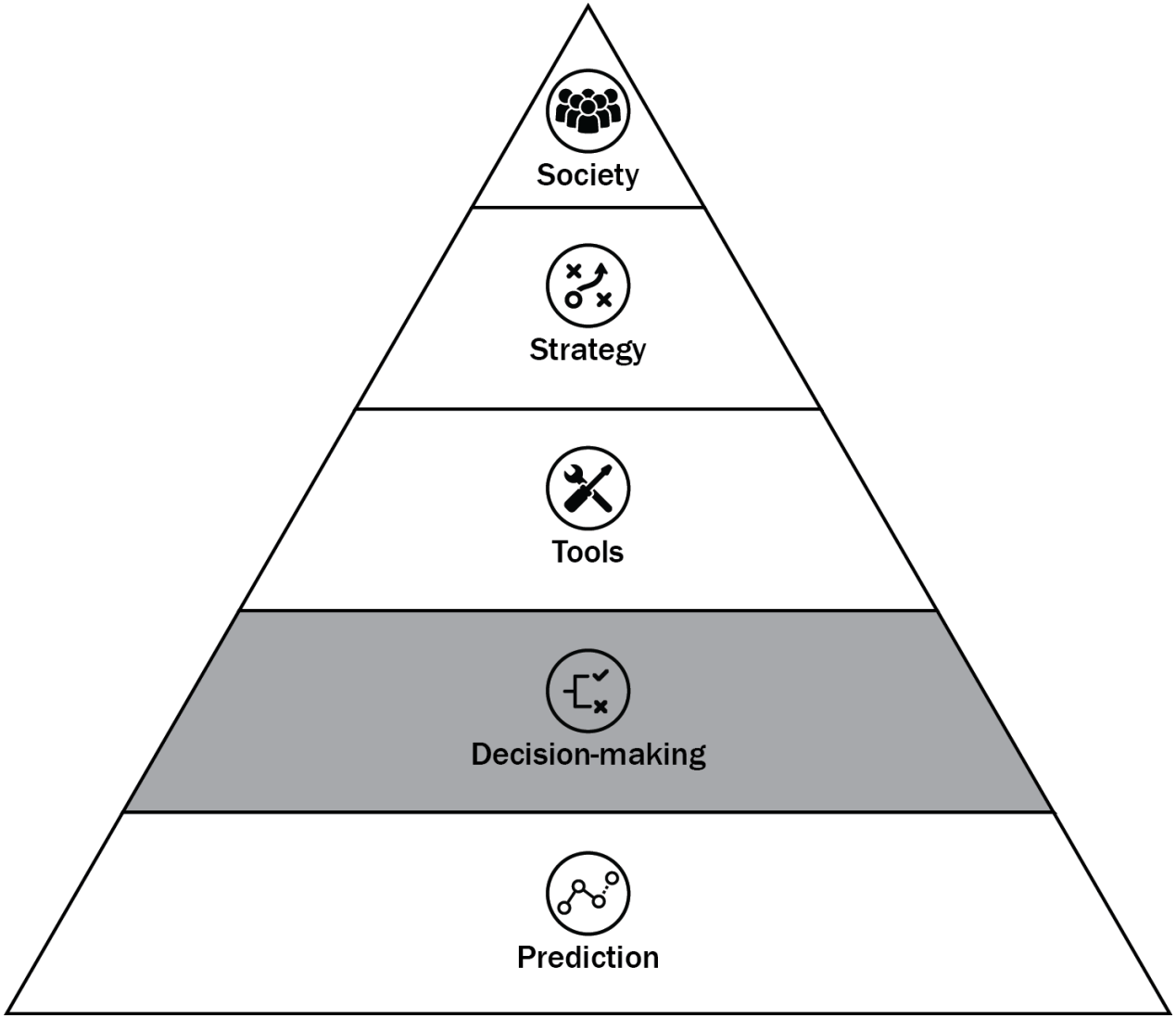
FIGURE 7-1

Anatomy of a task

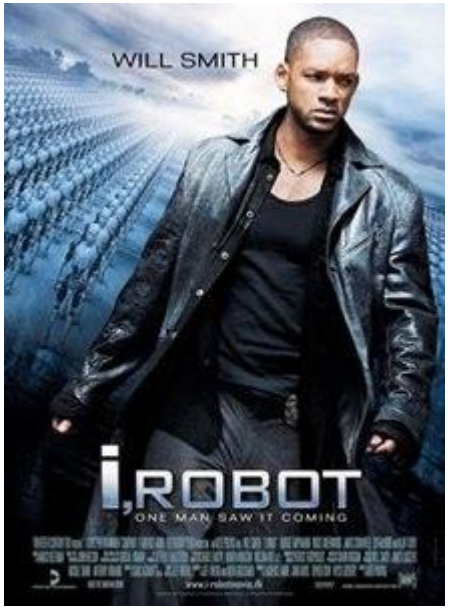


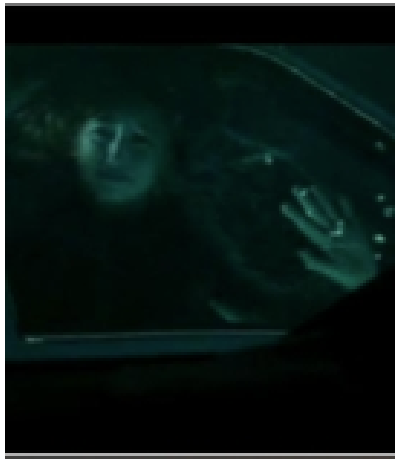
If AI is just prediction, then why the fuss?




Society
Strategy
Tools
Decision-making
Prediction

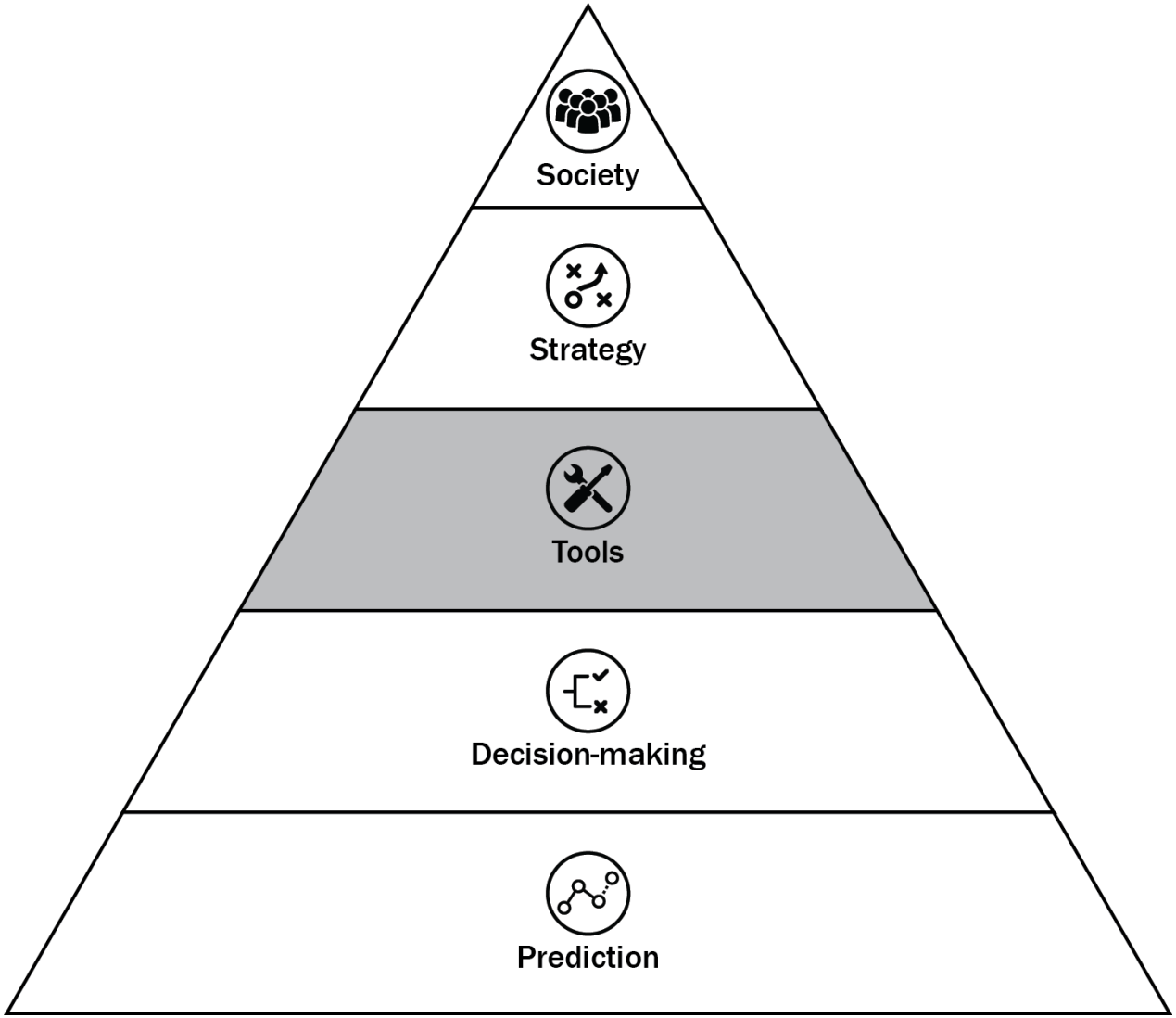
“I was the logical choice. It calculated that I had a 45% chance of survival. Sarah only had an 11% chance.





That was somebody's baby. 11% is more than enough.

A human being would've known that.”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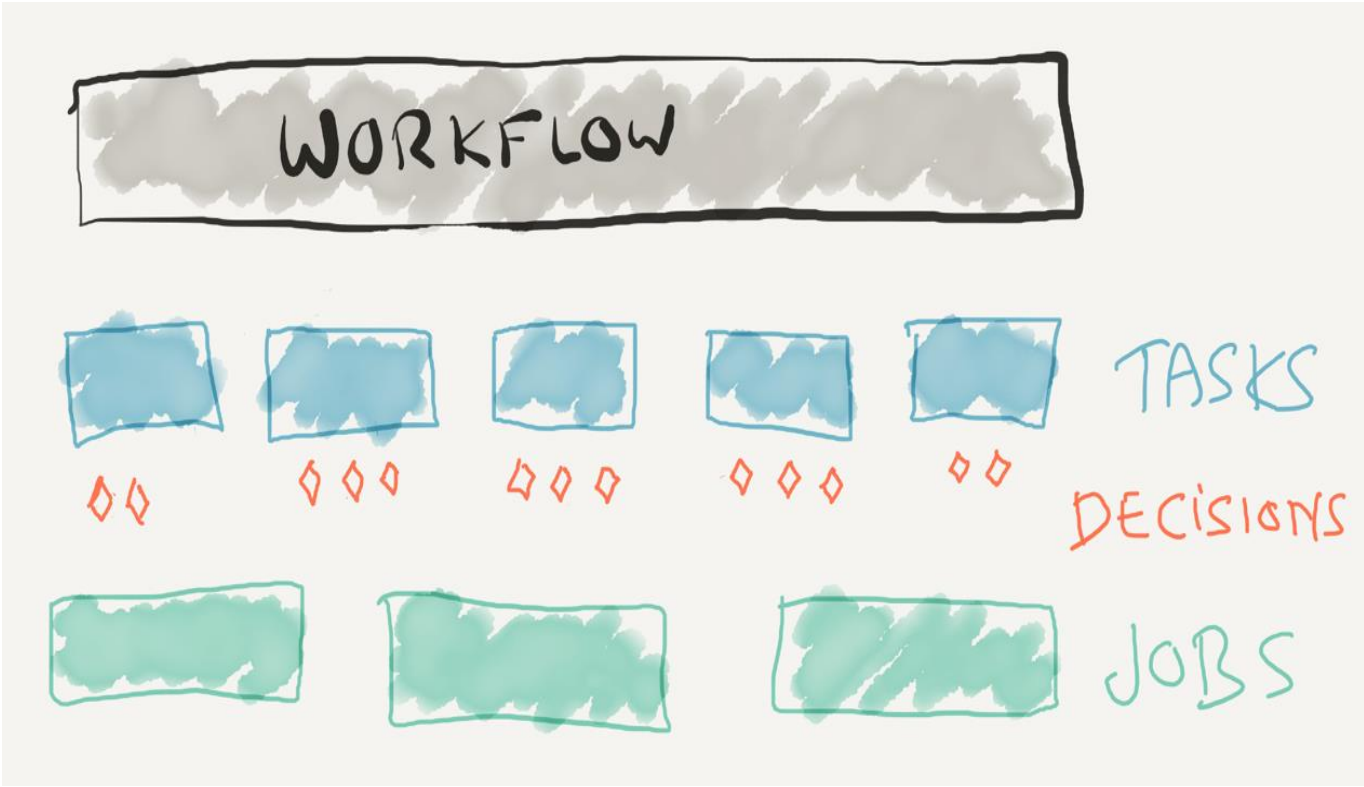

WORKFLOW
TASKS
DECISIONS
JOBS

Business Impact

As Goldman Embraces Automation, Even the Masters of the Universe Are Threatened

Software that works on Wall Street is changing how business is done and who profits from it.

by Nanette Byrnes February 7, 2017

Marty Chavez, Goldman Sachs's incoming CFO, has helped the firm become more automated.

At its height back in 2000, the U.S. cash equities trading desk at Goldman Sachs's New York headquarters employed 600 traders, buying and selling stock on the orders of the investment bank's large clients. Today there are just two equity traders left.

Now more complex areas of trading like currencies and credit, which are not traded on a stock exchange like the New York Stock Exchange but rather through less-transparent networks of traders, are coming in for more automation as well. To execute these trades, algorithms are being designed to emulate as closely as possible what a human trader would do, explains Coalition's Shahani.

Goldman Sachs has already begun to automate currency trading, and has found consistently that four traders can be replaced by one computer engineer, Chavez said at the Harvard conference. Some 9,000 people, about one-third of Goldman's staff, are computer engineers.

Next, Chavez said, will be the automation of investment banking tasks, work that traditionally has been focused on human skills like salesmanship and building relationships. Though those "rainmakers" won't be replaced entirely, Goldman has already mapped 146 distinct steps taken in any initial public offering of stock, and many are "begging to be automated," he said.

Reducing the number of investment bankers would be a great cost savings for the firm. Investment bankers working on corporate mergers and acquisitions at large banks like Goldman make on average $700,000 a year, according to Coalition, and in a good year they can earn far more.

ROBO REVOLUTION

Google has more than 1,000 artificial intelligence projects in the works

October 18, 2016

Google

Google's slew of big announcements in recent weeks — unveiling Google Translate's neat new machine learning tricks, its voice-controlled speaker system Home, and its new smartphone line Pixel (itself equipped with the futuristic-feeling virtual Assistant) — are evidence enough that the tech giant is investing heavily in artificial intelligence. But this *Fortune* story suggests that's just the tip of the iceberg: Google has dramatically ramped up its investments in what's known as "deep learning" in the last four years. In 2012, Google had two deep-learning projects underway. Today, Google has more than 1,000 deep-learning projects in every major product category, including search, maps, translation, and self-driving cars.

http://theweek.com/speedreads/654463/google-more-than-1000-artificial-intelligence-projects-works

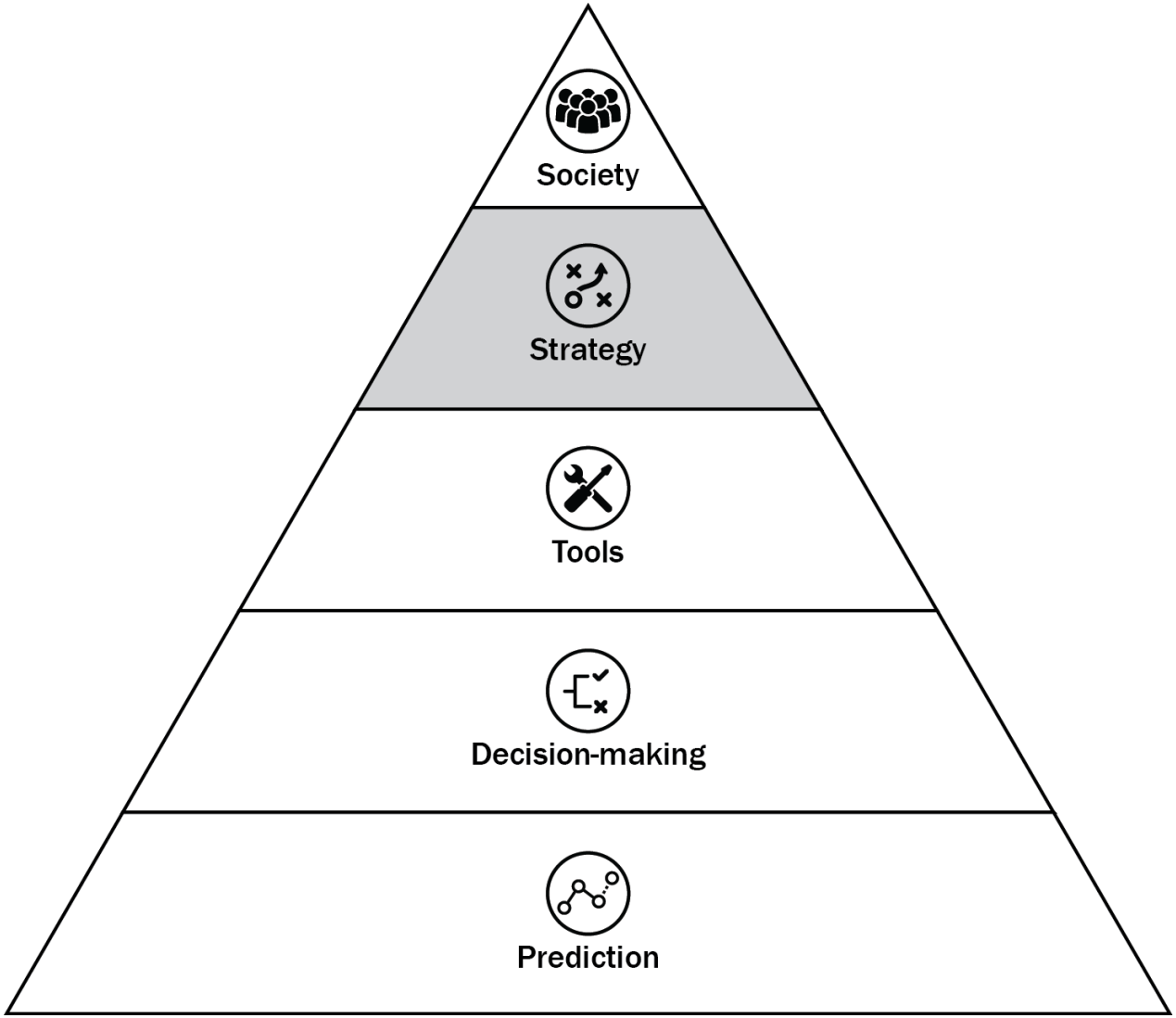
AI Canvas

Market:

Data

Prediction	Judgment	Action	Outcome

Training	Input	Feedback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NON-LINEAR BUSINESS RESPONSE TO LINEAR IMPROVEMENT IN AI

A THOUGHT EXPERIMENT


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–
+
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BAKERY & BREAD
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MEAT & SEAFOOD
MUSIC


MASTER VOLUME
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11
VOLUME

US008615473B2

(12) **United States Patent**
Spiegel et al.

(10) **Patent No.: US 8,615,473 B2**
(45) **Date of Patent: Dec. 24, 2013**

(54) **METHOD AND SYSTEM FOR ANTICIPATORY PACKAGE SHIPPING**

(75) Inventors: **Joel R. Spiegel**, Woodinville, WA (US); **Michael T. McKenna**, Bellevue, WA (US); **Girish S. Lakshman**, Issaquah, WA (US); **Paul G. Nordstrom**, Seattle, WA (US)

(73) Assignee: **Amazon Technologies, Inc.**, Reno, NV (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/594,195**

(22) Filed: **Aug. 24, 2012**

(65) **Prior Publication Data**

US 2012/0323645 A1 Dec. 20, 2012

Related U.S. Application Data

(62) Division of application No. 13/305,611, filed on Nov. 28, 2011, now Pat. No. 8,271,398, which is a division of application No. 11/015,288, filed on Dec. 17, 2004, now Pat. No. 8,086,546.

(51) **Int. Cl.**
G06Q 99/00 (2006.01)

(52) **U.S. Cl.**
USPC **705/332**; 705/330; 705/333; 705/336; 705/337

(58) **Field of Classification Search**
USPC 705/332, 330, 333, 336, 337
See application file for complete search history.

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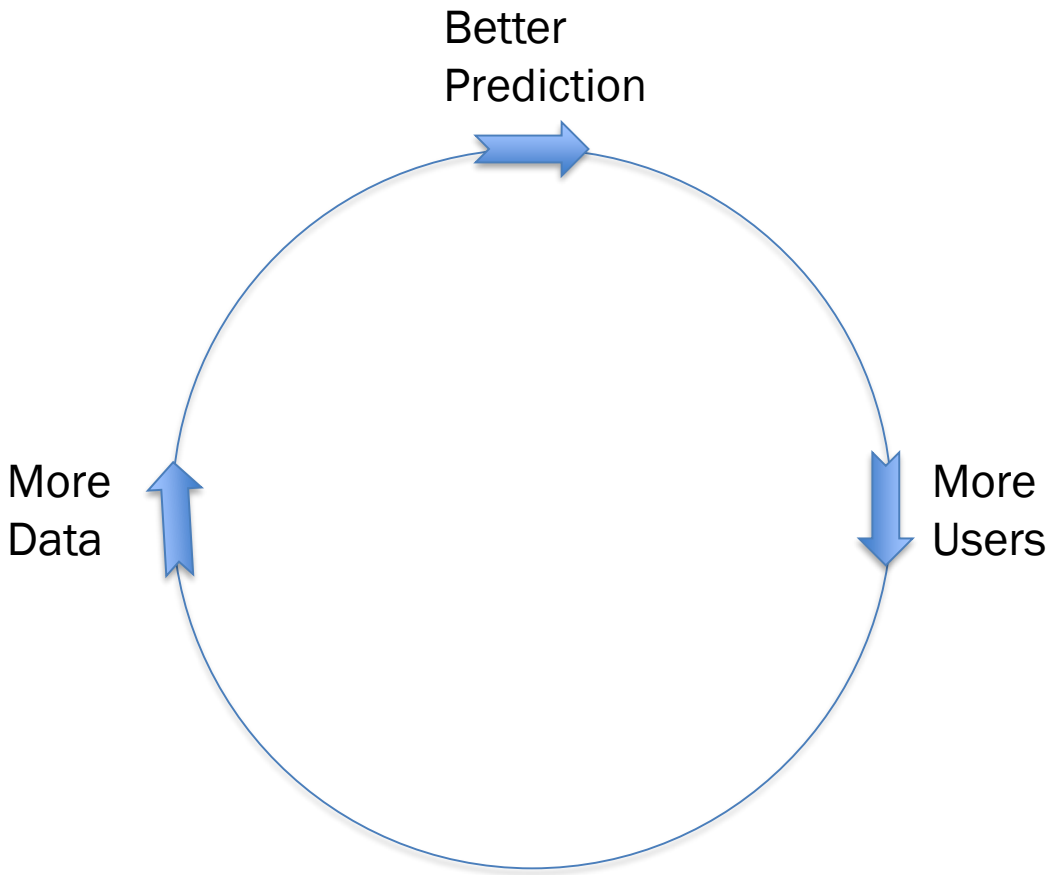
Primary Examiner — Akiba Allen
(74) *Attorney, Agent, or Firm* — Robert C. Kowert; Meyertons, Hood, Kivlin, Kowert & Goetzel, P.C.

(57) **ABSTRACT**

A method and system for anticipatory package shipping are disclosed. According to one embodiment, a method may include packaging one or more items as a package for eventual shipment to a delivery address, selecting a destination geographical area to which to ship the package, shipping the package to the destination geographical area without completely specifying the delivery address at time of shipment, and while the package is in transit, completely specifying the delivery address for the package.

24 Claims, 11 Drawing Sheets

FIRST MOVER ADVANTAGE


Better
Prediction
More
Users
More
Data

RE-ENGINEERING BUSINESS PROCESSES

The Productivity Paradox

“We see the computers everywhere but in the productivity statistics”

- Robert Solow

What took so long?

"At the turn of the century, farsighted engineers already had envisaged profound transformations that electrification would bring to factories, stores, and homes.

But the materialization of such visions hardly was imminent. In 1899 in the United States, electric lighting was being used in a mere 3 percent of all residences (and in only 8 percent of urban dwelling units); the horsepower capacity of all (primary and secondary) electric motors installed in manufacturing establishments in the country represented less than 5 percent of factory mechanical drive.

It would take another two decades, roughly speaking, for these aggregate measures of the extent of electrification to attain the 50 percent diffusion level."

- Paul David

US factory electrification movement

- Factory redesign
  - Group drives => unit drives
    - Lighter factory construction
    - Single story rather than multi-story
    - Optimize materials handling, flexible reconfiguration
    - Modularity => less downtime

- Replacement costs
  - American industries expanding in the early 20th century (tobacco, fabricated metals, transportation equipment, and electrical machinery) afforded the greatest immediate returns

Source: Paul David, American Economic Review, 1990


Mobile first to AI first

The New York Times | https://nyti.ms/2C7fSw1

TECHNOLOGY

Why A.I. Researchers at Google Got Desks Next to the Boss

By CADE METZ FEB. 19, 2018

MOUNTAIN VIEW, Calif. — If you want to understand the priorities of a technology company, first look at the seating chart.

At Google's Silicon Valley headquarters, the chief executive, Sundar Pichai, now shares a floor with Google Brain, a research lab dedicated to artificial intelligence.

A year ago, the Google Brain team of mathematicians, coders and hardware engineers sat in a small office building on the other side of the company's campus. But over the past few months, it switched buildings and now works right beside the loungelike area where Mr. Pichai and other top executives work.

Timing => Strategy

Google Acquires Artificial Intelligence Startup DeepMind For More Than $500M

Posted Jan 26, 2014 by Catherine Shu (@catherineshu)

SELF-DRIVING CARS

GM Buying Self-Driving Tech Startup for More Than $1 Billion

Dan Primack, Kirsten Korosec
Mar 11, 2016

John Deere Acquires AI Startup Blue River Technology for $305 Million

Thursday, Sep. 7th, 2017

TD adds to tech capabilities with $100-million deal for AI firm Layer 6 - The Globe and Mail

Toronto-Dominion Bank has agreed to buy a one-year-old artificial-intelligence startup with just 17 employees for more than $100-million (U.S.), snapping up Canadian machine-learning talent that has been in hot demand from the world's technology giants.

The target company, Toronto-based Layer 6 Inc., hadn't yet advanced beyond turning proof-of-concept work it had done for several clients – including TD – into regular, revenue-generating business. However, other early stage AI firms have also sold out for handsome sums to global companies, including Canada's Maluuba, purchased last year by Microsoft – which paid largely for its AI know-how rather than its actual business.

The New York Times | https://nyti.ms/2GtQlwz

TECHNOLOGY

Pentagon Wants Silicon Valley's Help on A.I.

By CADE METZ MARCH 15, 2018

SAN FRANCISCO — There is little doubt that the Defense Department needs help from Silicon Valley's biggest companies as it pursues work on artificial intelligence. The question is whether the people who work at those companies are willing to cooperate.

On Thursday, Robert O. Work, a former deputy secretary of defense, announced that he is teaming up with the Center for a New American Security, an influential Washington think tank that specializes in national security, to create a task force of former government officials, academics and representatives from private industry. Their goal is to explore how the federal government should embrace A.I. technology and work better with big tech companies and other organizations.

There is a growing sense of urgency to the question of what the United States is doing in artificial intelligence. China has vowed to become the world's leader in A.I. by 2030, committing billions of dollars to the effort. Like many other officials from government and industry, Mr. Work believes the United States risks falling behind.

"The question is, how should the United States respond to this challenge?" he said. "This is a Sputnik moment."


Thank you
ajay@agrawal.ca