Intro to Artificial Intelligence and Machine Learning

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Deep Learning and AI

- Deep Learning is part of a broader field known as Machine Learning.
- Machine Learning is part of a broader field known as Artificial Intelligence.
- What is Artificial Intelligence?
  - Easy part: Artificial.
  - Hard part: Intelligence.

Biological World




Artificial World

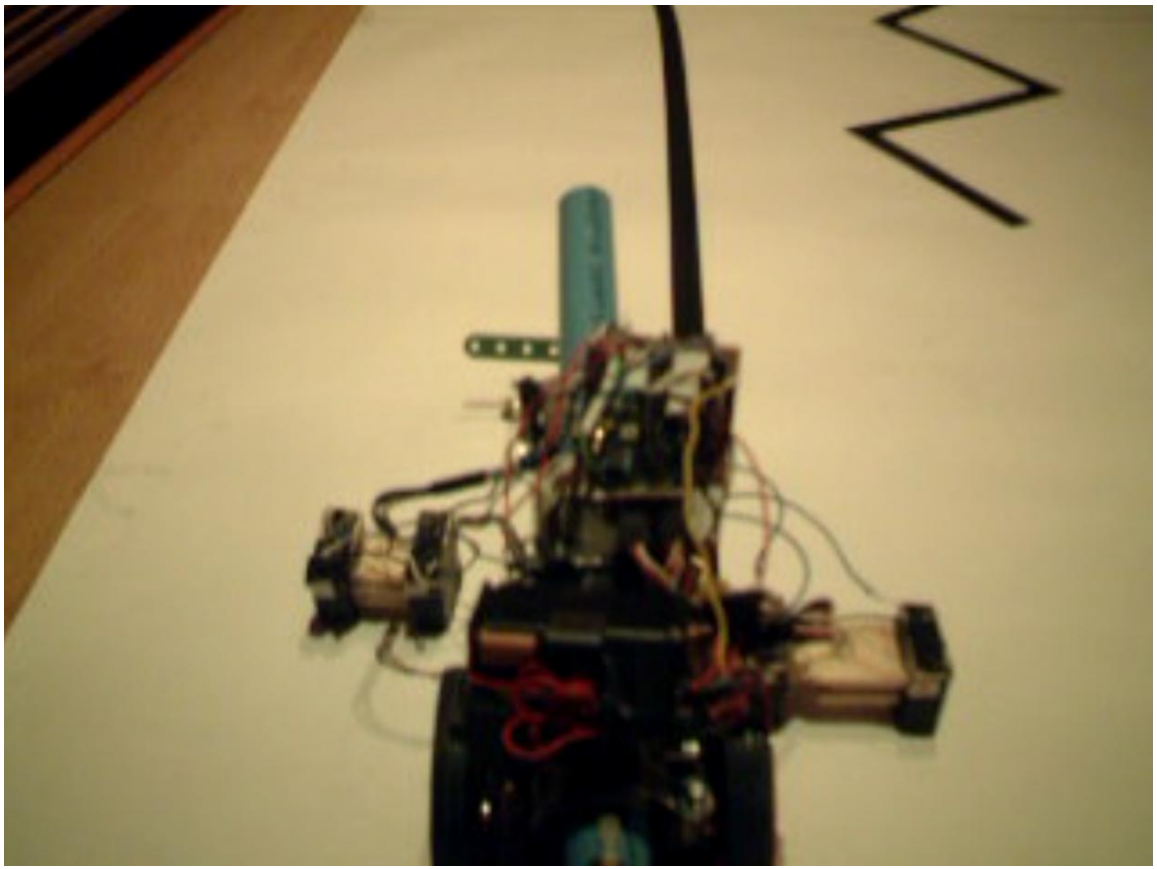
Artificial Intelligence

Study of computational models that allow machines to perceive, reason, and act with great flexibility.

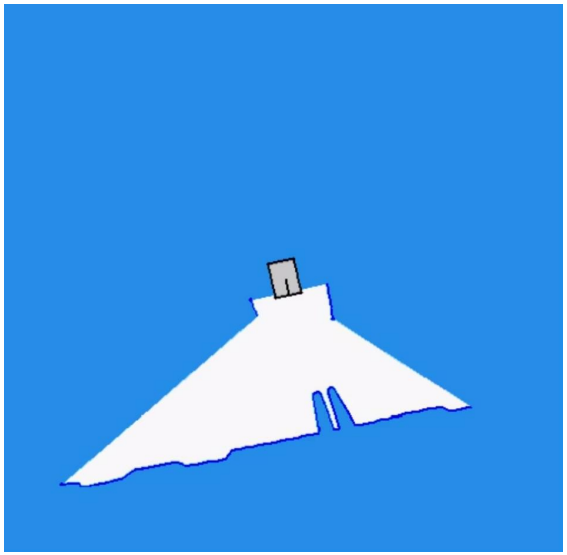
Artificial Intelligence

Study of computational models that allow machines to acquire a level of understanding of its world.

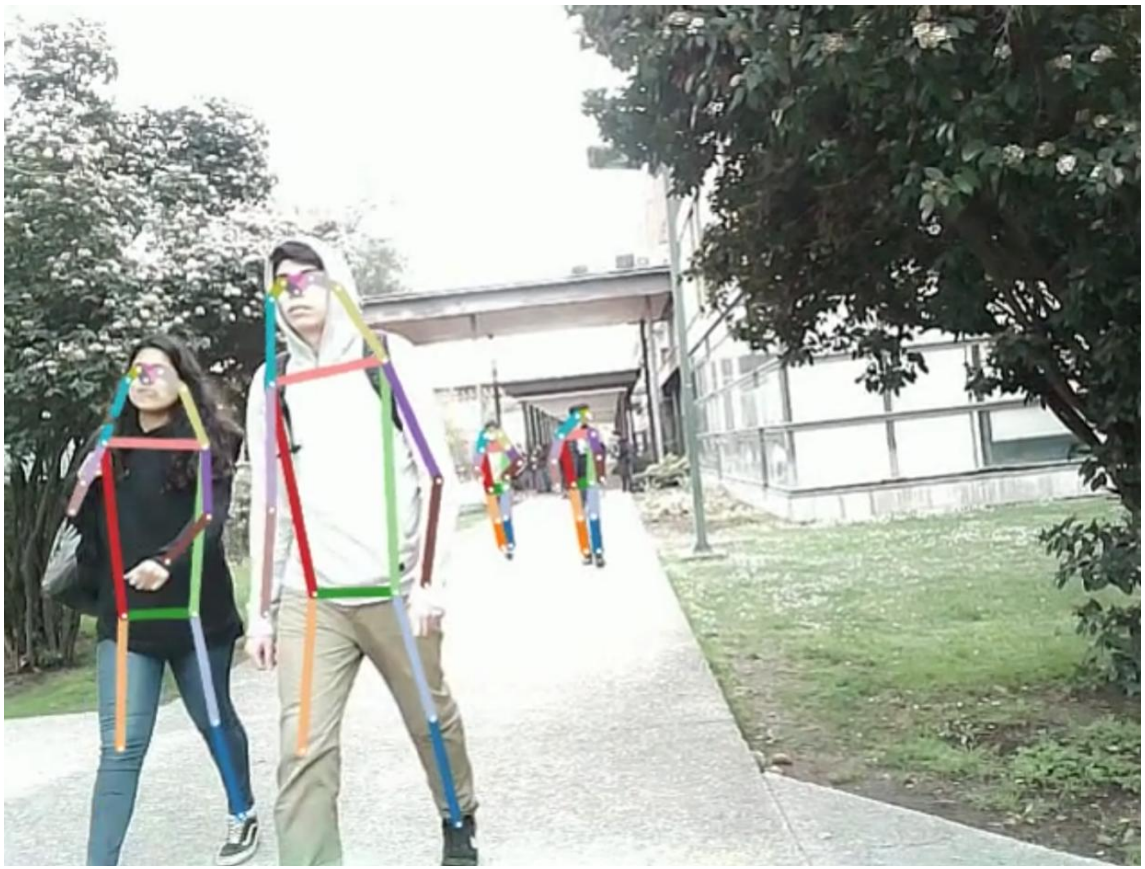
Understanding: Year 2001



Understanding: Year 2005



Understanding: Year 2022



Understanding: Year 2022

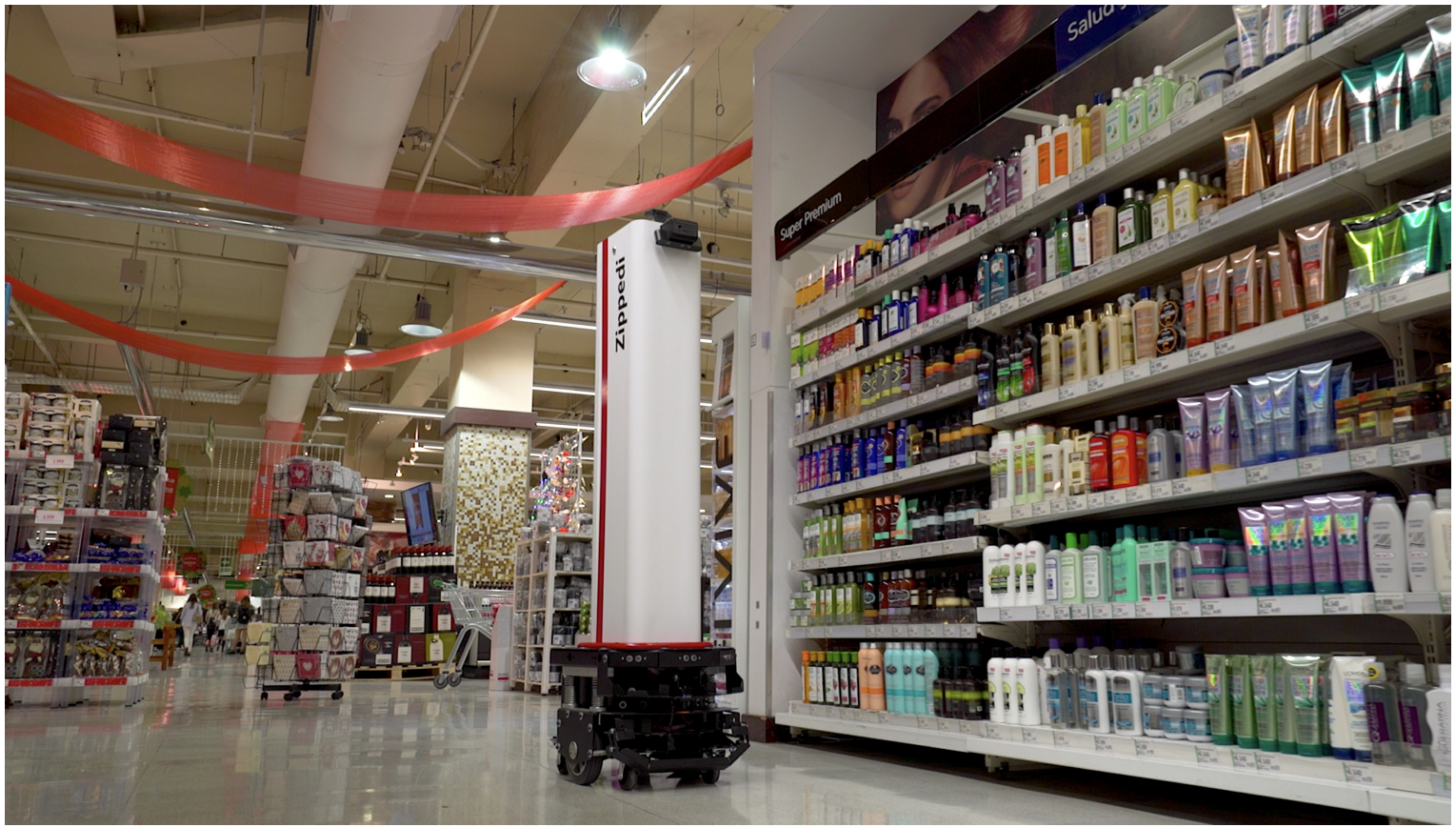
Understanding: Year 2022

Text summarization

cia documents reveal iot-specific televisions can be used to secretly record conversations .
cybercriminals who initiated the attack managed to commandeer a large number of internet-connected devices in current use .
cia documents revealed that microwave ovens can spy on you - maybe if you personally don't suffer the consequences of the sub-par security of the iot .

Internet of Things (IoT) security breaches have been dominating the headlines lately . WikiLeaks's trove of CIA documents revealed that internet-connected televisions can be used to secretly record conversations . Trump's advisor Kellyanne Conway believes that microwave ovens can spy on you - maybe she was referring to microwave cameras which indeed can be used for surveillance . And don't delude yourself that you are immune to IoT attacks , with 96 % of security professionals responding to a new survey expecting an increase in IoT breaches this year . Even if you personally don't suffer the consequences of the sub-par security of the IoT , your connected gadgets may well be unwittingly cooperating with criminals . Last October , Internet service provider Dyn came under an attack that disrupted access to popular websites . The cybercriminals who initiated the attack managed to commandeer a large number of internet-connected devices (mostly DVRs and cameras) to serve as their helpers . As a result , cybersecurity expert Bruce Schneier has called for government regulation of the IoT , concluding that both IoT manufacturers and their customers don't care about the security of the 8.4 billion internet-connected devices in current use . Whether because of government regulation or good old-fashioned self-interest , we can expect increased investment in IoT security technologies . In its recently-released TechRadar report for security and risk professionals , Forrester Research discusses the outlook for the 13 most relevant and important IoT security technologies , warning that " there is no single , magic security bullet that can easily fix all IoT security issues . " Based on Forrester's analysis , here's my list of the 6 hottest technologies for IoT security : IoT network security : Protecting and securing the network connecting IoT devices to back-end systems on the internet . IoT network security is a bit more challenging than traditional network security because there is a wider range of communication protocols , standards , and device capabilities , all of which pose significant issues and increased complexity . Key capabilities include traditional endpoint security features such as antivirus and antimalware as well as other features such as firewalls and intrusion prevention and detection systems . Sample vendors : Bayshore Networks , Cisco , Darktrace , and Senrio . IoT authentication : Providing the ability for users to authenticate an IoT device , including managing multiple users of a single device (such as a connected car) , ranging from simple static password/pins to more robust authentication mechanisms such as two-factor

Understanding: Year 2022



Some History

- 60's : Era of optimism or naiveness.
  - Deductive learning.
- 70's - 80's: Era of pessimism.
- 90's: Era of reborn.
- 2000's: Era of Machine Learning.
  - Inductive learning.

Inductive learning

This bird can fly

This bird can fly

This bird can fly

This bird can fly

Can this bird fly ?

Inductive learning

This bird can fly

This bird can fly

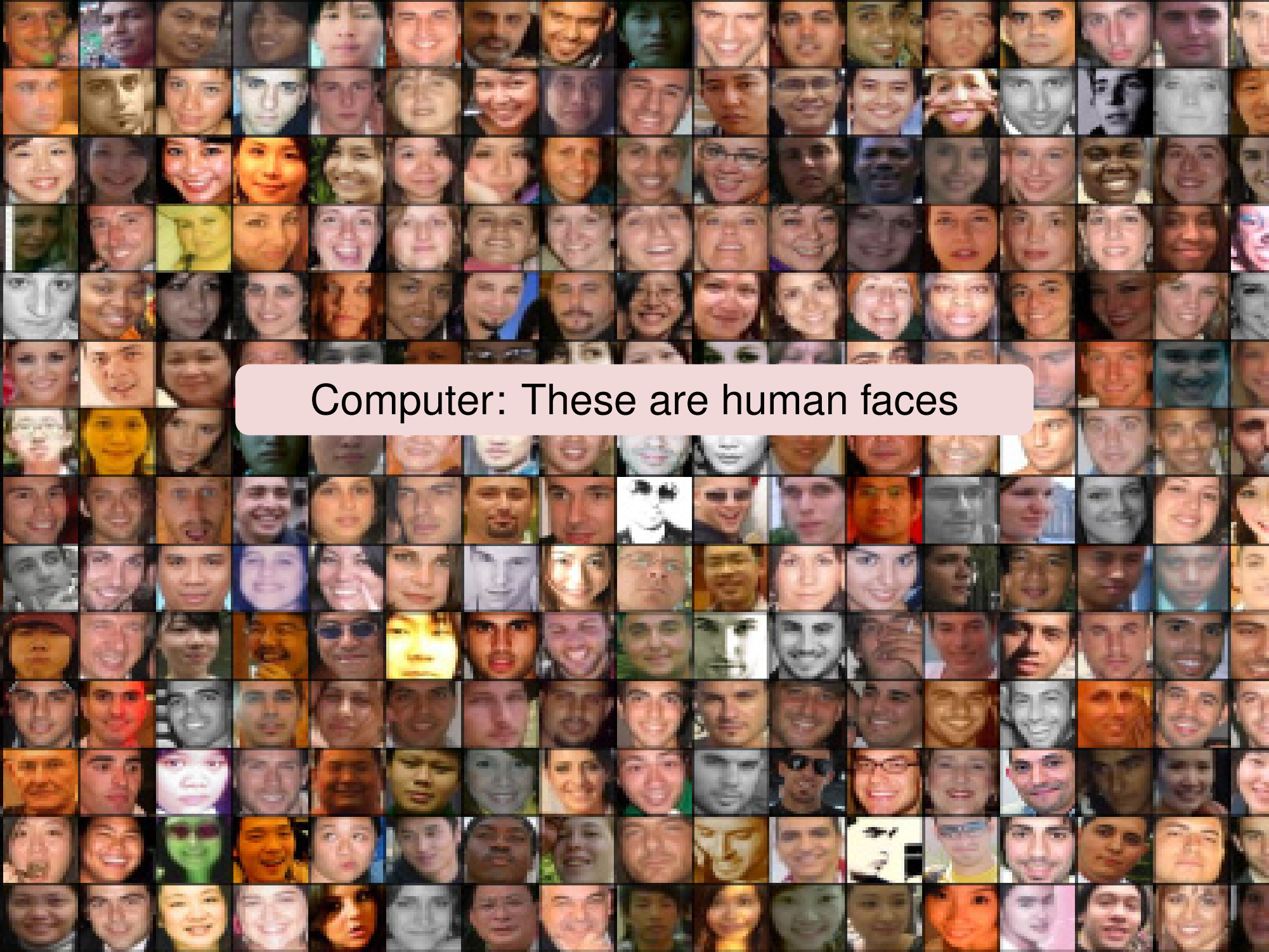
This bird can fly

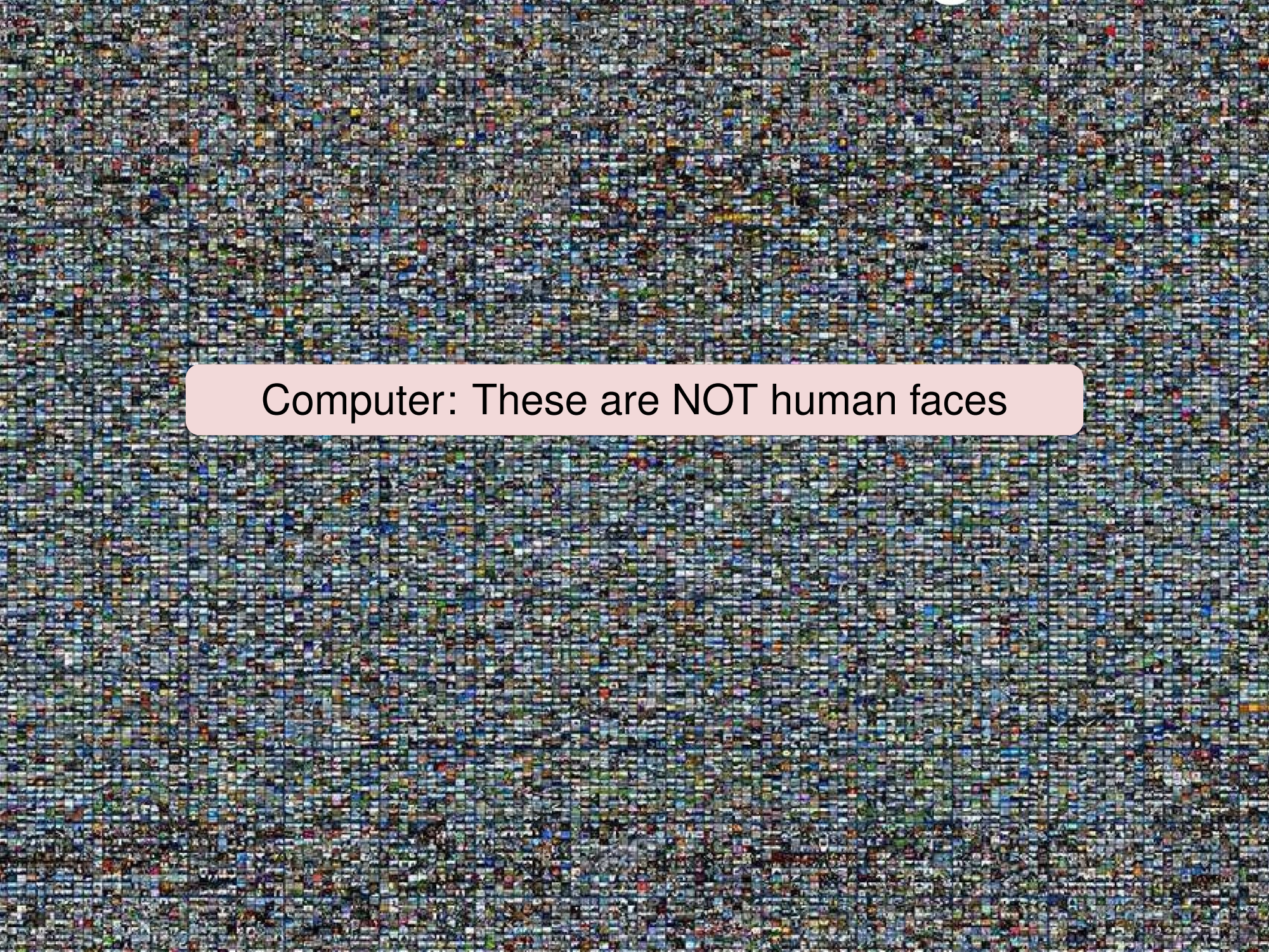
This bird can fly

Can this bird fly ?

Machine Learning

Computational programs (algorithms) that learn from experience, i.e., data.


Computer: These are human faces


Computer: These are NOT human faces

Computer: Any human face?

AI: Modern View (Rusell and Norvig)

An intelligent agent (or intelligent machine) perceives, reasons, and acts with great flexibility.

Machine learning (ML)

An intelligent agent learns from experience

AI: This course perspective

An intelligent agent is able to acquire a level of understanding of its world.

ML: This course perspective

- Learning from experience to build useful representations to understand the world.
- Then use these representation to make prediction, take decision, etc.

Structured vs.Unstructured data

Structured data

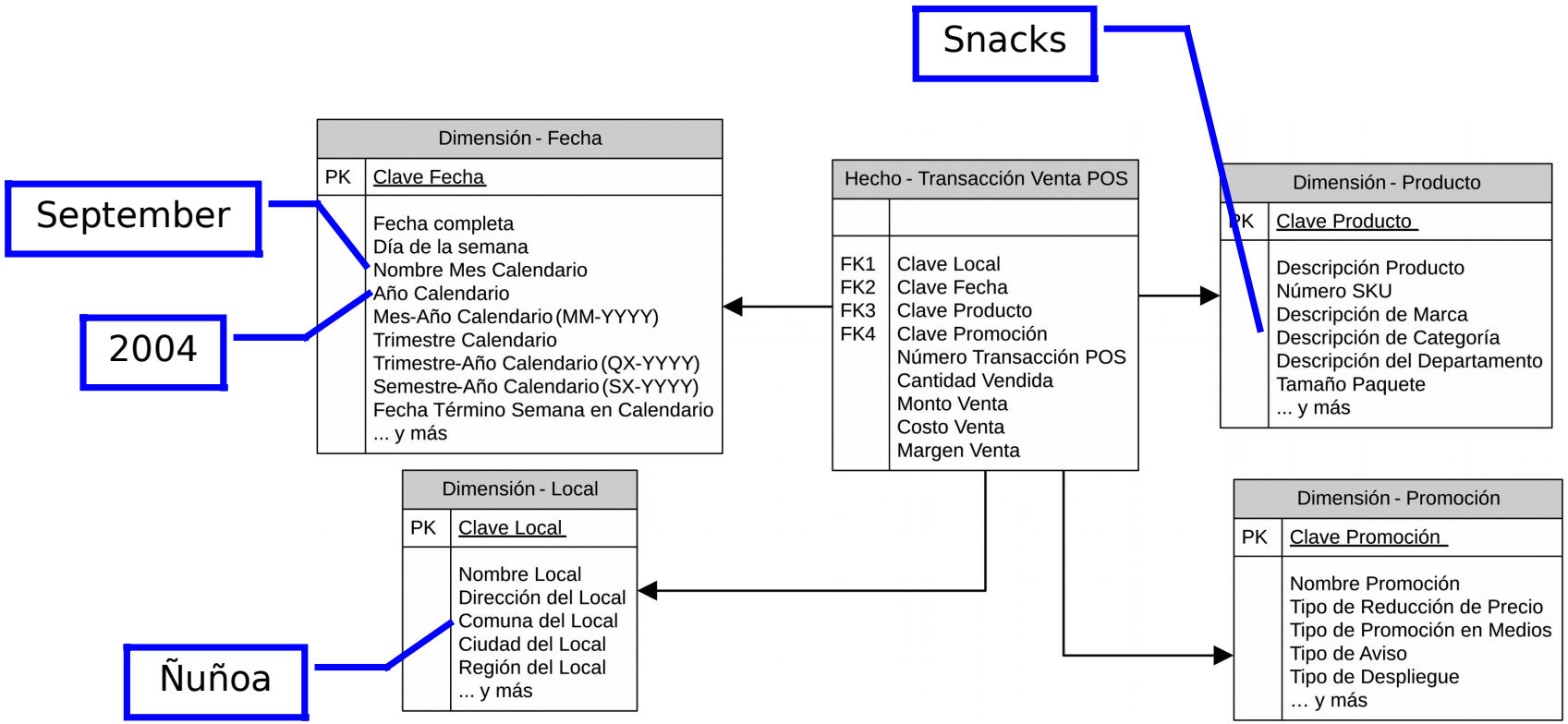
Data that is well organized (SQL stuff).

```
SELECT *
    FROM Book
    WHERE price > 100
    ORDER BY title;
```

Unstructured data

Data that is complex and not well organized.

Computer: snacks in Ñuñoa, September 2004?



Unstructured data

Computer: What's going on?

Structured vs.Unstructured data

Structured data

Data that is well organized (SQL stuff).

```
SELECT *
    FROM Book
    WHERE price > 100
    ORDER BY title;
```

Unstructured data

Data that is complex and not well organized.

In simpler terms:

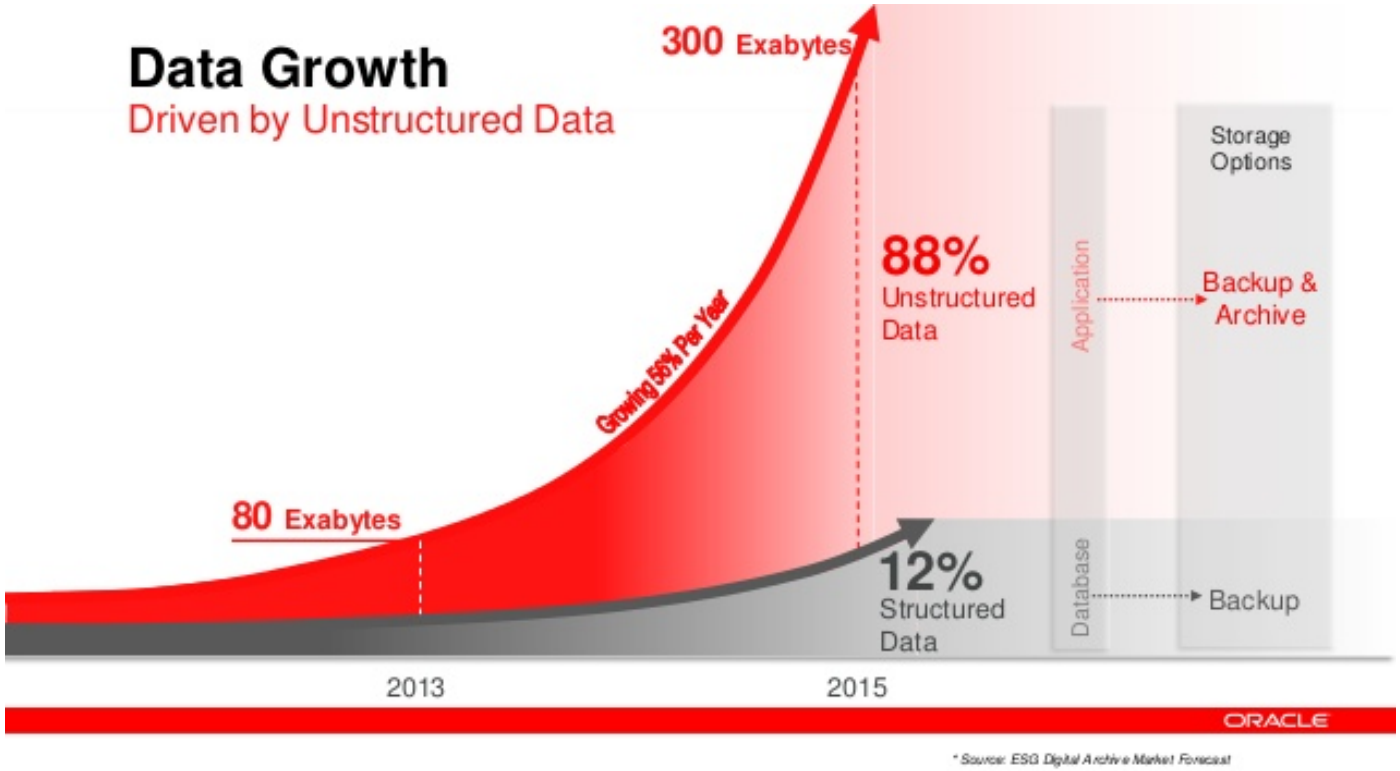
Structured data

Data that today's computers **can** undertand.

Unstructured data

Data that today's computers **can't** understand.

Structured vs. Unstructured data



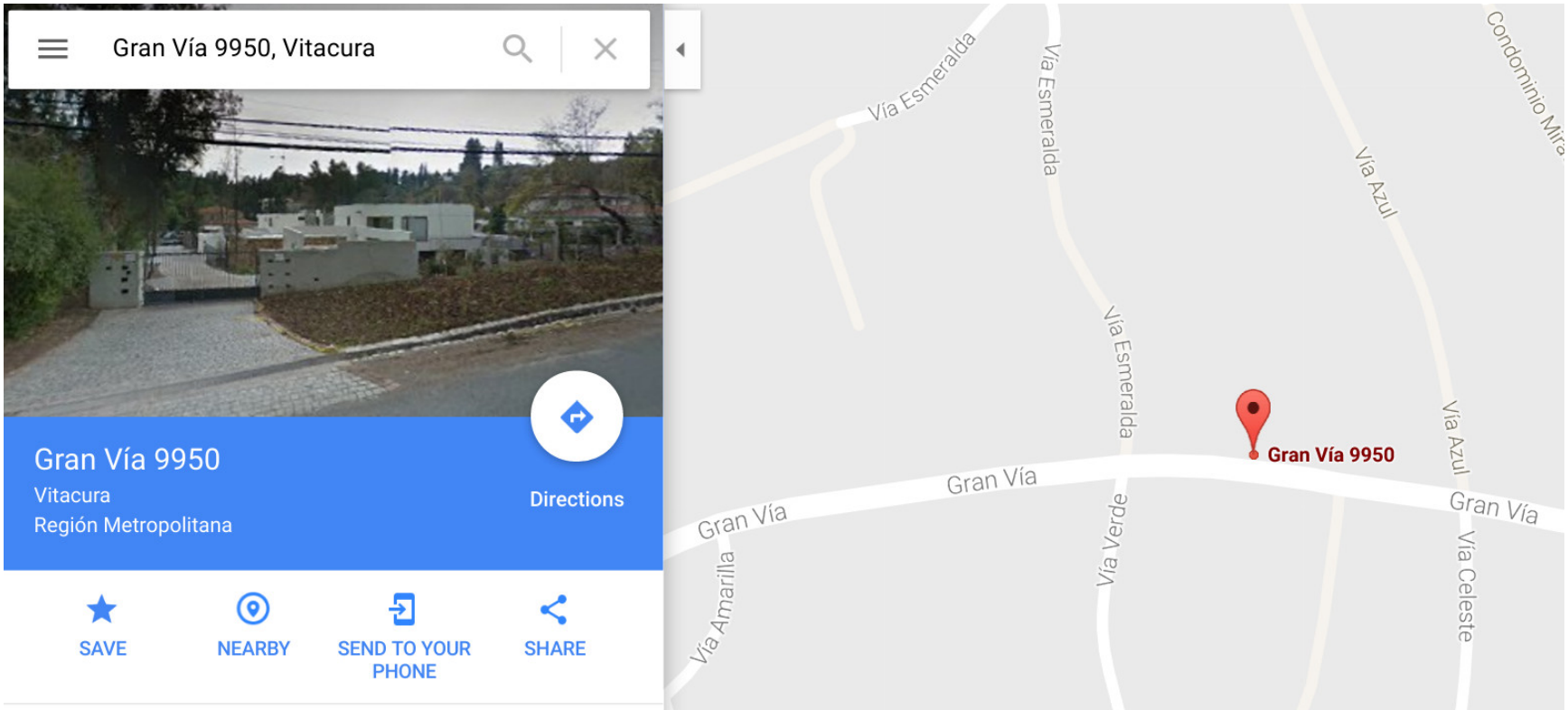
Machine Learning and Big Data

- As we discussed, Machine Learning is about learning from data.
- Currently, Big Data is it's great ally.
- By providing large sources of data, Big Data is increasing the accuracy of machine learning techniques.
- The synergistic combination between machine learning and big data is a key element behind the sucess of deep learning.

Good experience, i.e. data, is key to learn.

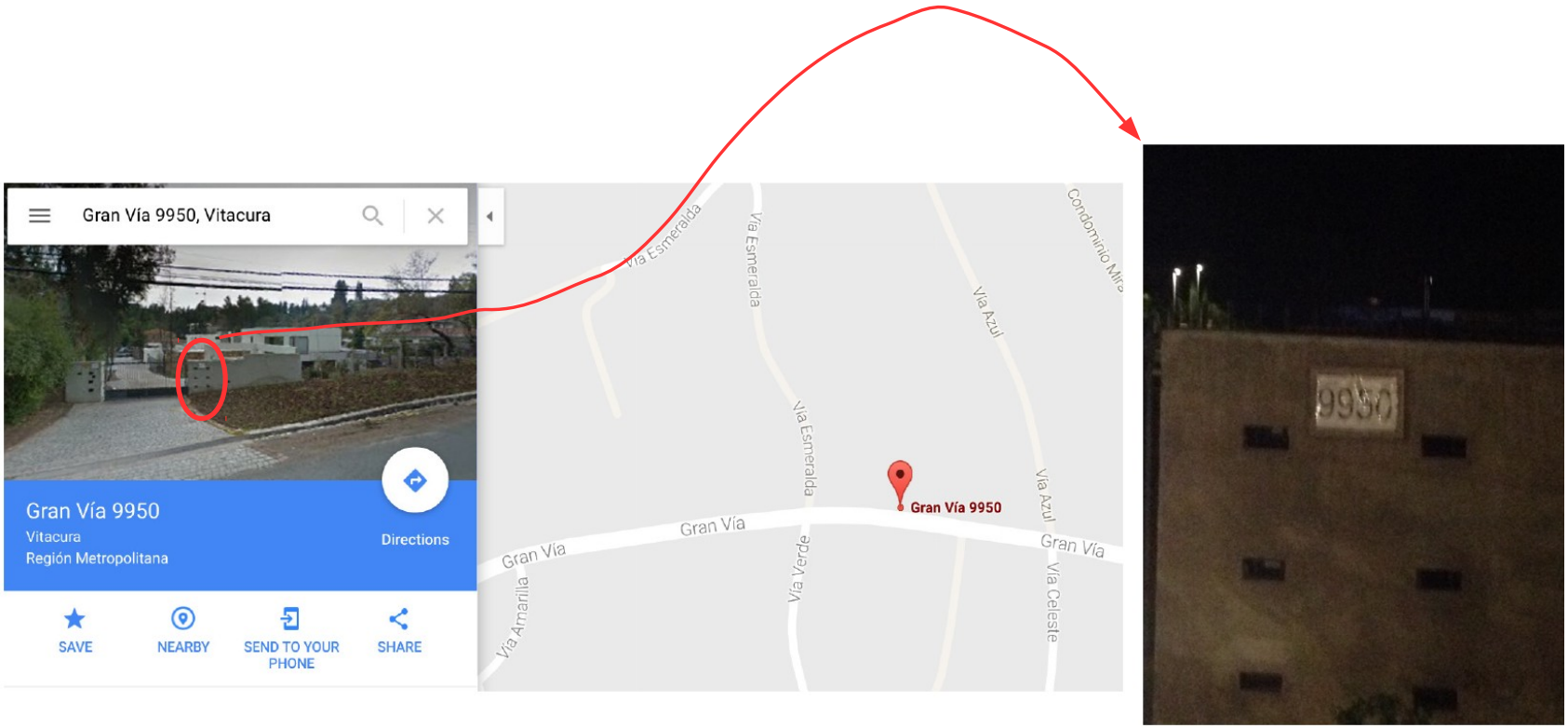
Experience is key

Example: Google Street View.



Experience is key

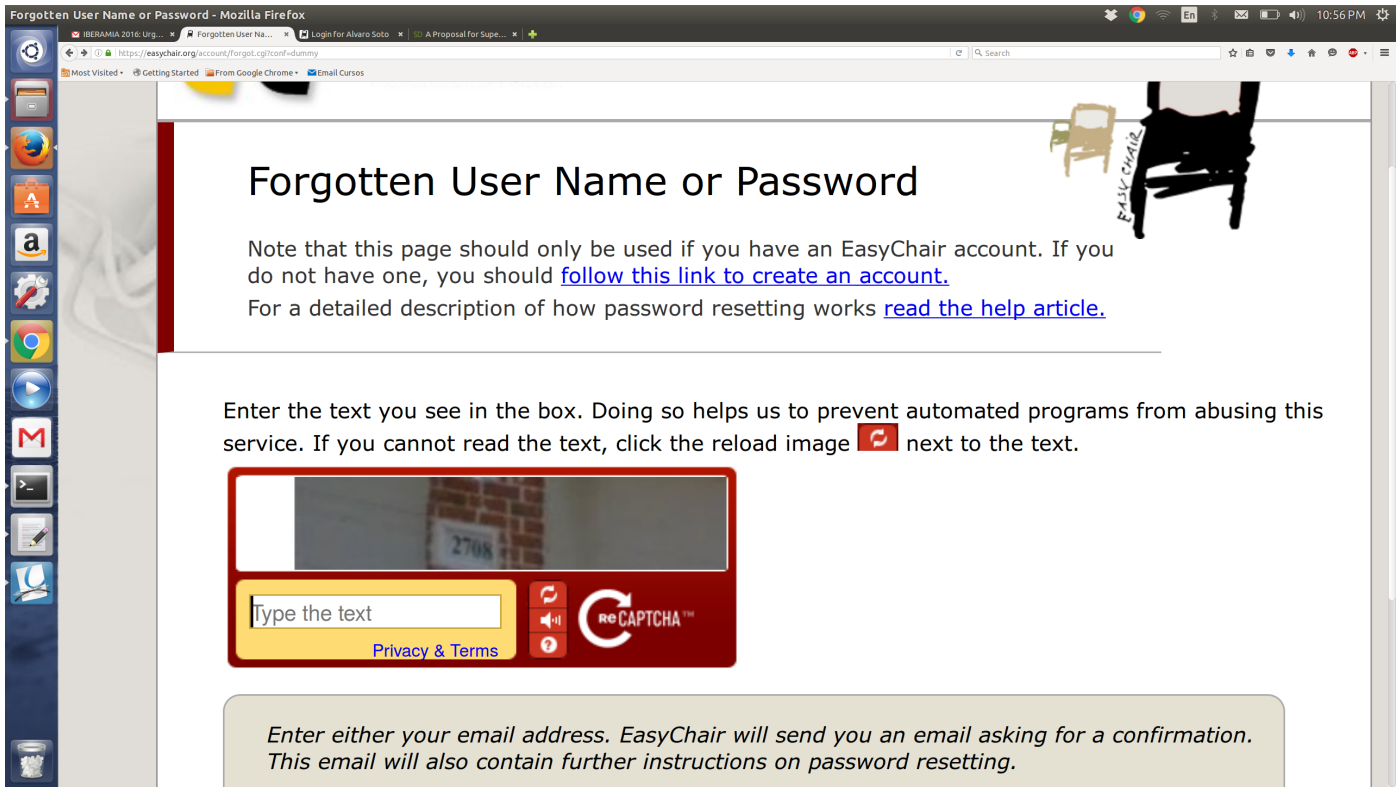
Example: Google Street View.



How can they do this?

Experience is key

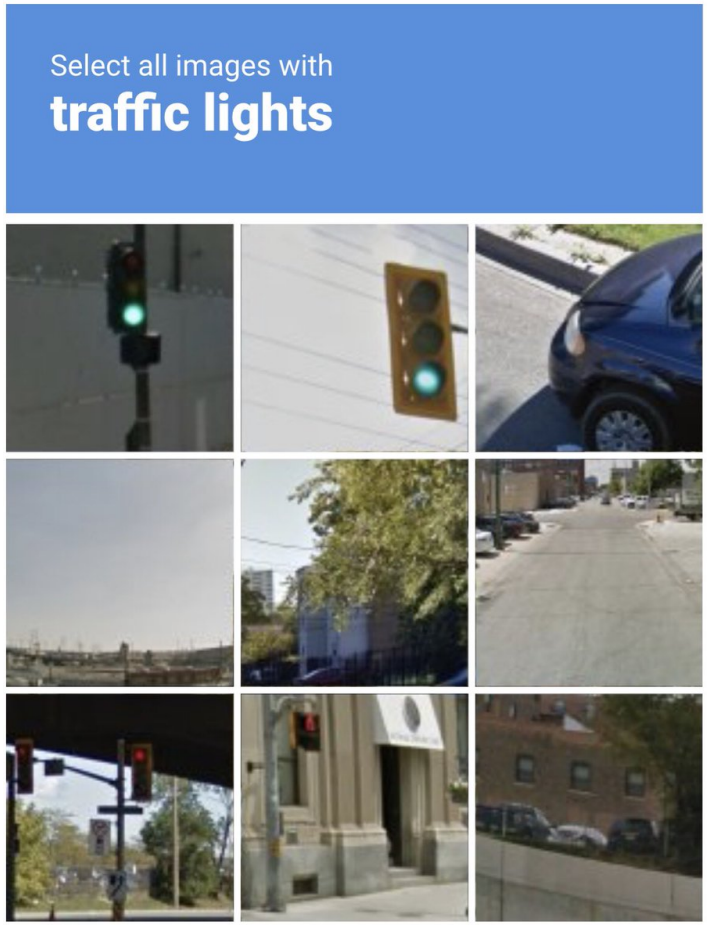
Example: Google Street View.



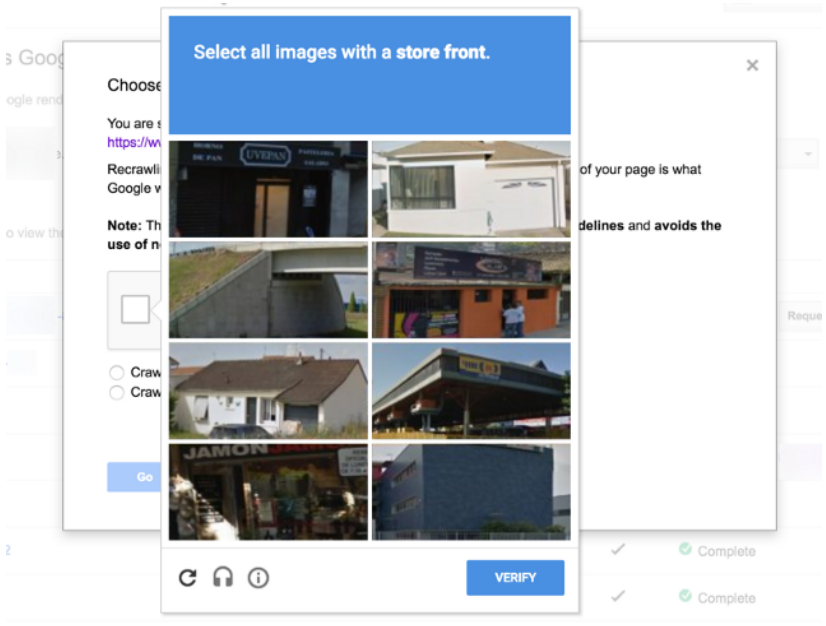
Experience is key: Training Data

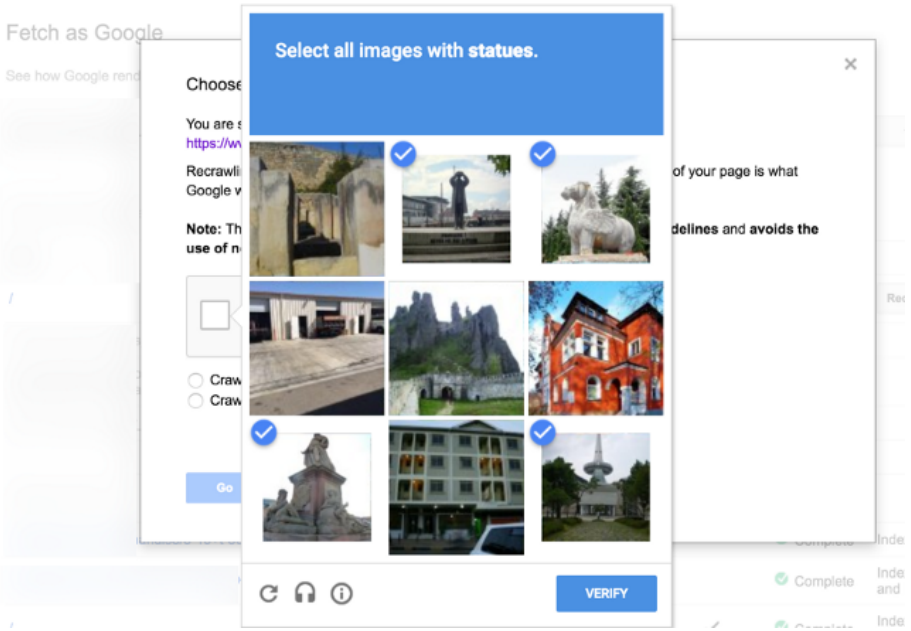
http://research.google.com/pubs/pub42241.html

Experience is key: Training Data

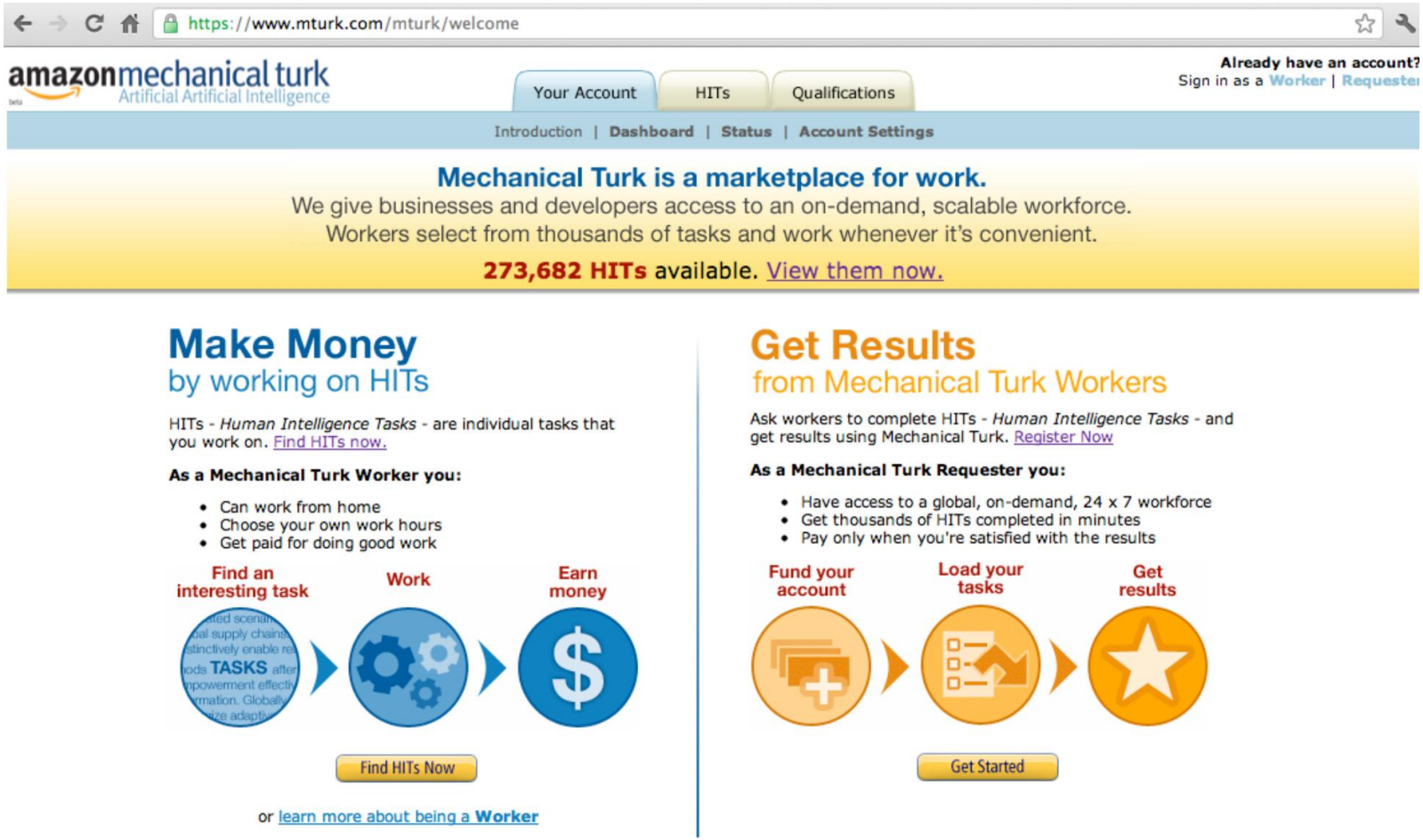


Experience is key: Training Data

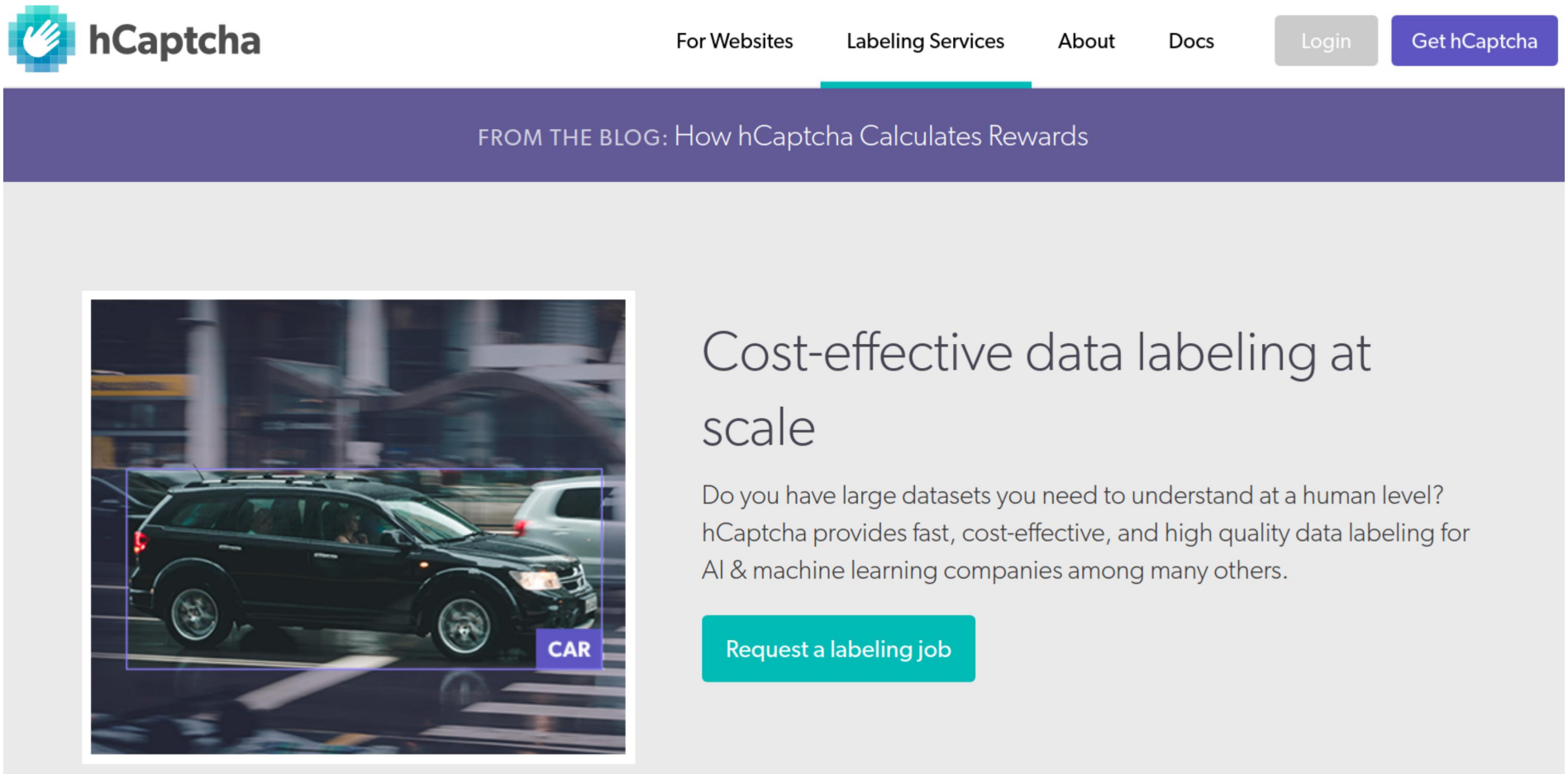




Experience is key: Crowdsourcing and Human Computation



Experience is key: Crowdsourcing and Human Computation

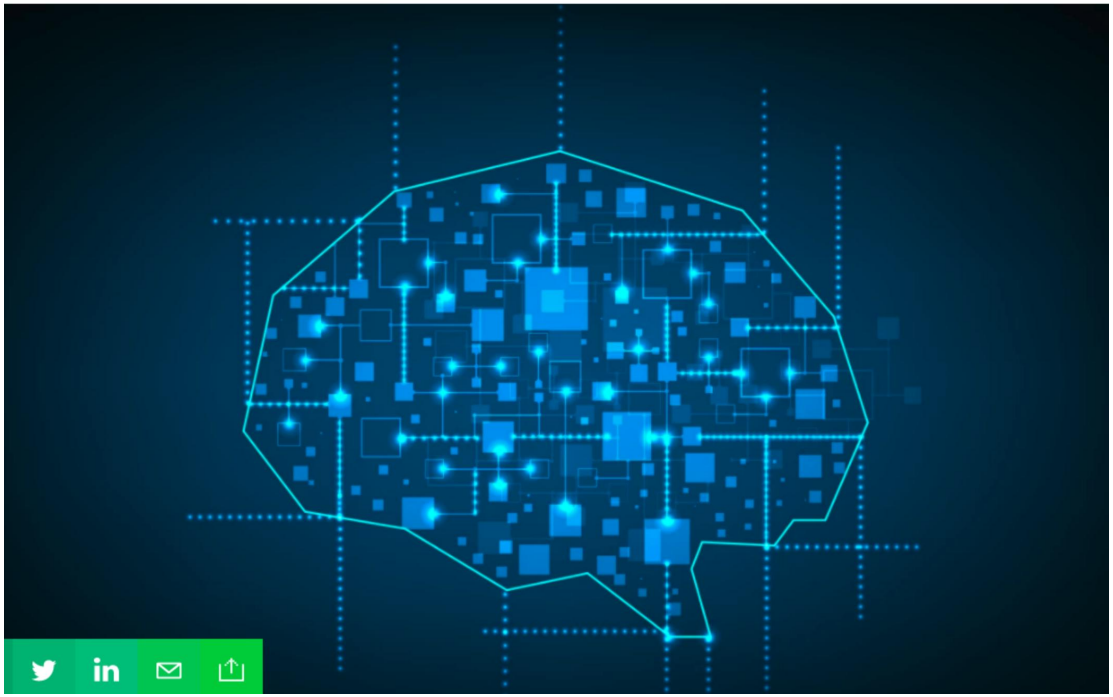


Experience is key: Crowdsourcing and Human Computation

Appen acquires Figure Eight for up to $300M, bringing two data annotation companies together

Anthony Ha @anthonyha / 4 hours ago

Comment



10/03/2019

Experience

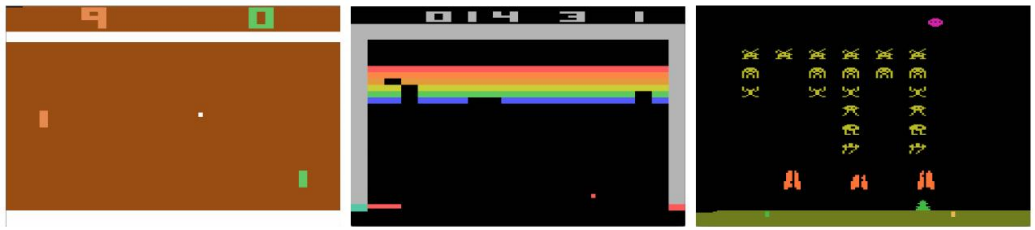
So far we have been focusing on a learning paradigm known as: Supervised learning. However, depending of the type of training data available and the goals of the learning process, we can find several popular learning paradigms:

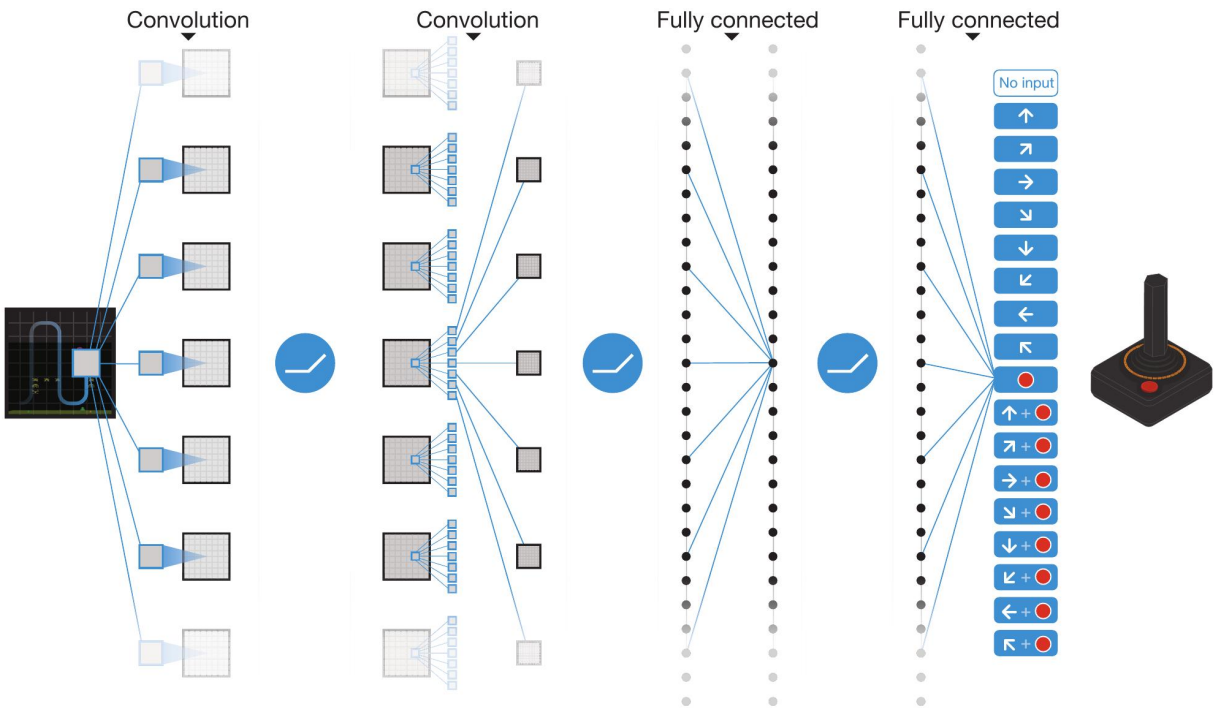
- Supervised learning.
- Unsupervised learning.
- Reinforcement learning.
- Semi-supervised learning.
- Active learning.
- Structural learning.
- Supervised clustering.
- Instance based learning.
- ...

As we will discuss in this course, all these learning frameworks are just different ways to provide semantic to the learning process (grounding).

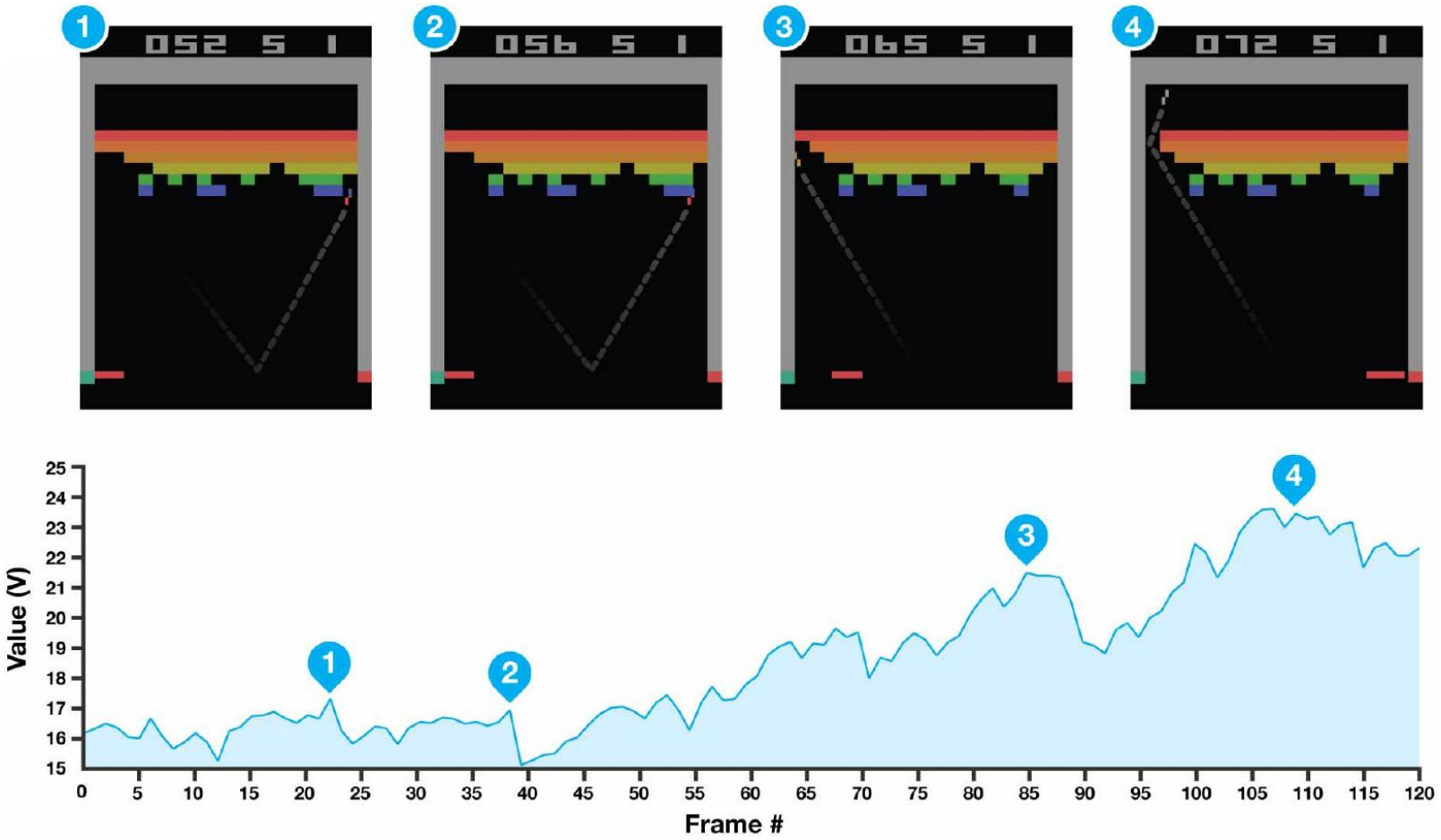
Reinforcement learning

Learning to play Atari games (Mnih et al., NIPS-2014)

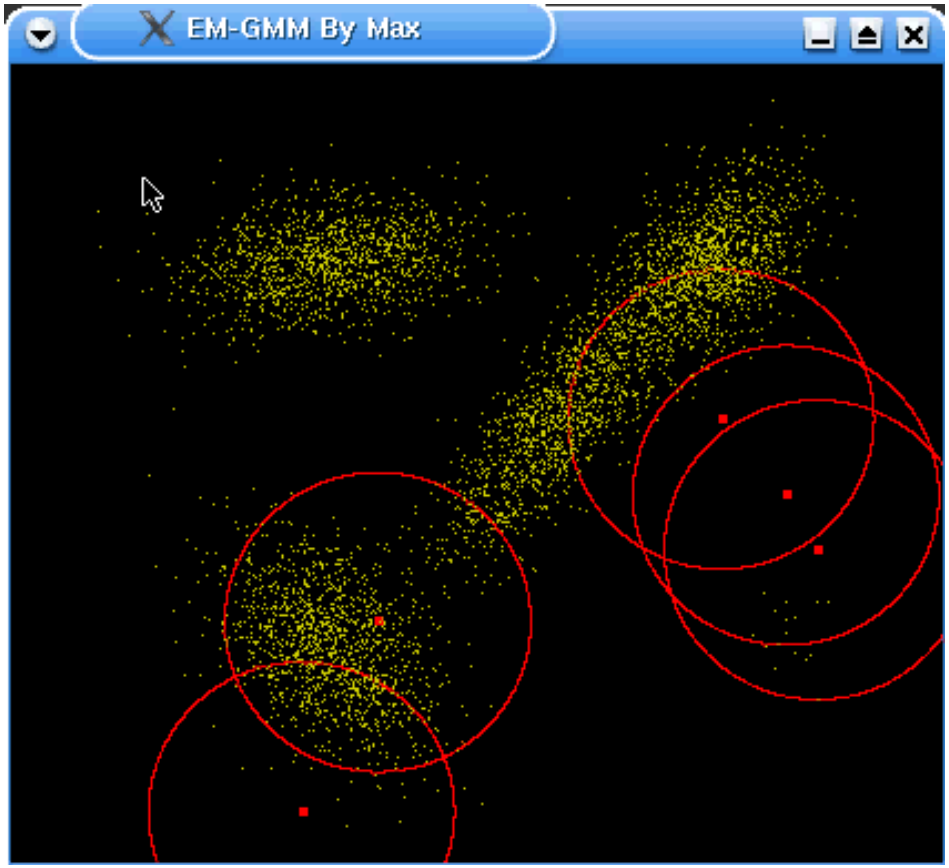




Reinforcement learning



Unsupervised Learning



Self-supervised Learning

Machine Learning

Any computer program that improves its performance at some task through experience.

A computer program is said to learn from experience E with respect to some class of task T and performance measure P, if its performance for tasks in T, as measured by P, improves with experience E.

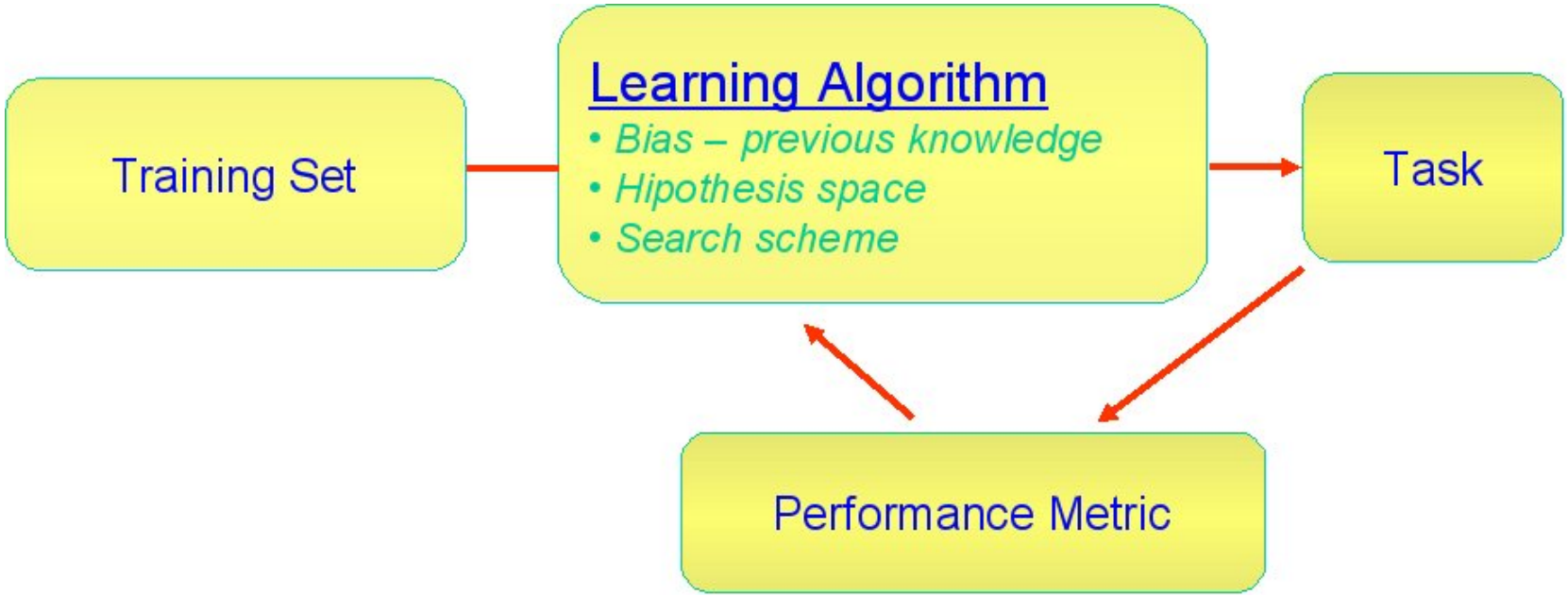
Key assumption of Inductive Machine Learning

Any hypothesis that approximates a target function well over a sufficiently large set of training examples will also approximate this target function well over unobserved examples.

- OJO The previous assumption requires that the training data must be representative of the target concept or function.

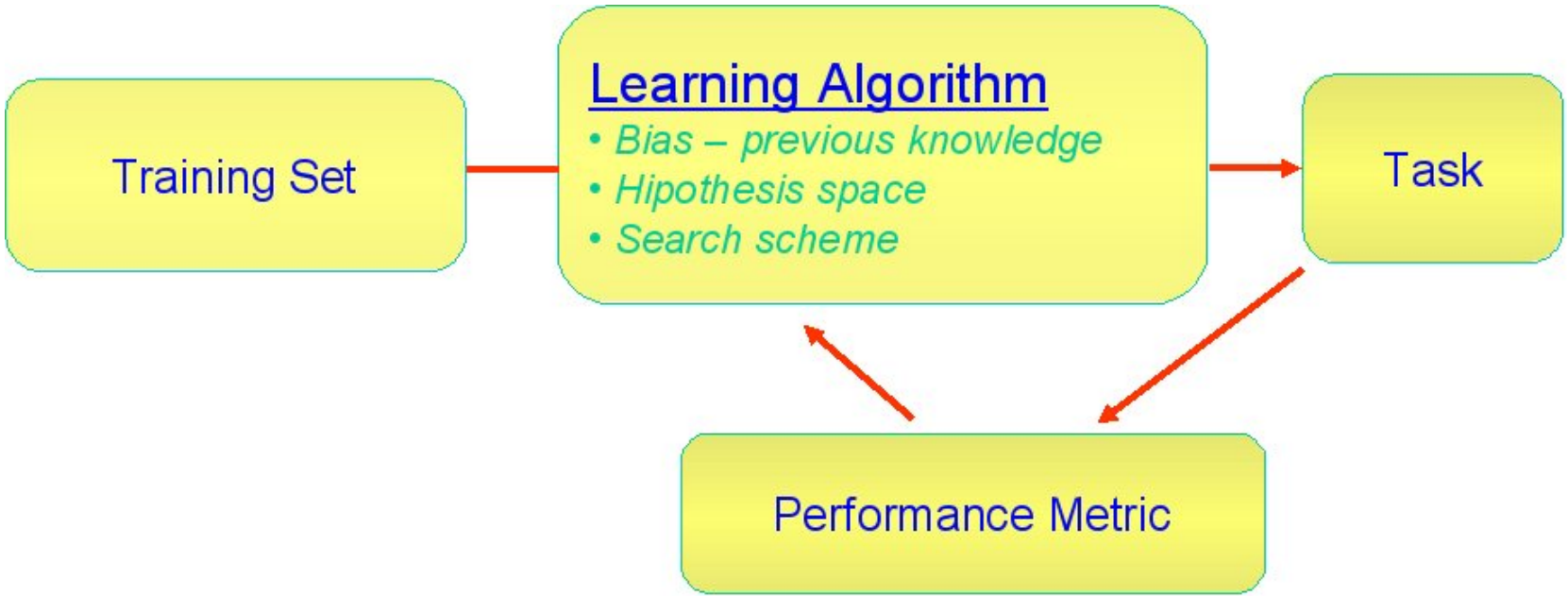
Machine Learning: Generic View

Learning involves searching through a space of possible hypotheses to find a hypothesis that provides a suitable (best) fit to the available training data and prior constraints (previous knowledge).



OJO There is a new element: previous knowledge. . . Any comment?

Machine learning, 3 main ingredients:
Representation + Performance + Optimization.



Machine learning, 3 main ingredients:
Representation + Performance + Optimization.

Machine learning problem

$$f^* = \arg\min_{f \in \mathcal{H}} \mathcal{L}(f(x)) = \arg\min_{f \in \mathcal{H}} \int_{x_i \in T} \mathcal{L}(f(x_i)) d_T$$

We usually approximate this using a training set Tr:

$$f^* \approx f^*_{Tr} = \arg\min_{f \in \mathcal{H}} \frac{1}{N} \sum_{x_i \in Tr}^{N} \mathcal{L}(f(x_i))$$

$\mathcal{H}$: hypothesis space.
$\mathcal{L}$: loss function
f^*: optimal hypothesis in $\mathcal{H}$ under $\mathcal{L}$.

Generic machine learning loss

$$f^* \approx f^*_{Tr} = \arg\min_{f \in \mathcal{H}} \frac{1}{N} \sum_{x_i \in Tr}^{N} \mathcal{L}(f(x_i))$$

Supervised learning

$$f^*_{Tr} = \arg\min_{f \in \mathcal{H}} \frac{1}{N} \sum_{x_i, y_i \in Tr}^{N} \mathcal{L}(f(x_i), y_i)$$

Hypothesis space

- Models have limits (suitable representation?).
- Search in complex spaces (non-lineal or convex) is usually a hard and exhausting process (right optimization tool and performance metric?).

Risks,

- If the hypothesis space is too flexible, there is a higher risk to converge to misleading hypothesis (suffer overfitting problems).
- If the search tool is too limited, there is a higher risk to being unable to find a good hypothesis (converge to local optimals).

Concepts that you should know about ML.

- Classical AI and ML views.
- Generic view of ML.
- Main elements of a ML technique: Representation + Performance + Optimization.
- Supervised and unsupervised ML.
- Overfitting.
- Training, test, validation sets.

Recommended concepts that you should review. We will discuss some of them in future lectures:

- All the ideas in this week lecture: “A Few Useful Things to Know About Machine Learning” by Pedro Domingos.

Tapping into the "folk knowledge" needed to advance machine learning applications.

BY PEDRO DOMINGOS

A Few Useful Things to Know About Machine Learning

MACHINE LEARNING SYSTEMS automatically learn programs from data. This is often a very attractive alternative to manually constructing them, and in the last decade the use of machine learning has spread rapidly throughout computer science and beyond. Machine learning is used in Web search, spam filters, recommender systems, ad placement, credit scoring, fraud detection, stock trading, drug design, and many other applications. A recent report from the McKinsey Global Institute asserts that machine learning (a.k.a. data mining or predictive analytics) will be the driver of the next big wave of innovation.[15] Several fine textbooks are available to interested practitioners and researchers (for example, Mitchell[16] and Witten et al.[24]). However, much of the "folk knowledge" that is needed to successfully develop machine learning applications is not readily available in them. As a result, many machine learning projects take much longer than necessary or wind up producing less-than-ideal results. Yet much of this folk knowledge is fairly easy to communicate. This is the purpose of this article.

» key insights

- **Machine learning algorithms can figure out how to perform important tasks by generalizing from examples. This is often feasible and cost-effective where manual programming is not. As more data becomes available, more ambitious problems can be tackled.**
- **Machine learning is widely used in computer science and other fields. However, developing successful machine learning applications requires a substantial amount of "black art" that is difficult to find in textbooks.**
- **This article summarizes 12 key lessons that machine learning researchers and practitioners have learned. These include pitfalls to avoid, important issues to focus on, and answers to common questions.**