Introduction to Machine Learning

20CP401T

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Introduction

Can you recognize these images?

How do you recognize it?

Origin of Machine Learning?

…..Lies in very early efforts of understanding Intelligence.

What is Intelligence?

It can be defined as the ability to comprehend; to understand and profit from experience.

Capability to acquire and Apply Knowledge.

What is Machine Learning?

It is very hard to write programs that solves problems like recognizing handwritten documents, recognizing a 3D object from a novel viewpoint in new lighting conditions in a cluttered scene.

- We don’t know what program to write because we don’t know how its done in our brain.

- Even if we had a good idea about how to do it , the program might be extremely complicated.

Machine Learning Approach

Instead of writing a program by hand for each specific task, we collect lots of examples that specify the correct out put for a given input.

A machine learning algorithm then takes these examples and produces a program that does the job.

- The program produced by the learning algorithm may look very different from a typical hand-written program. It may contain millions of numbers.

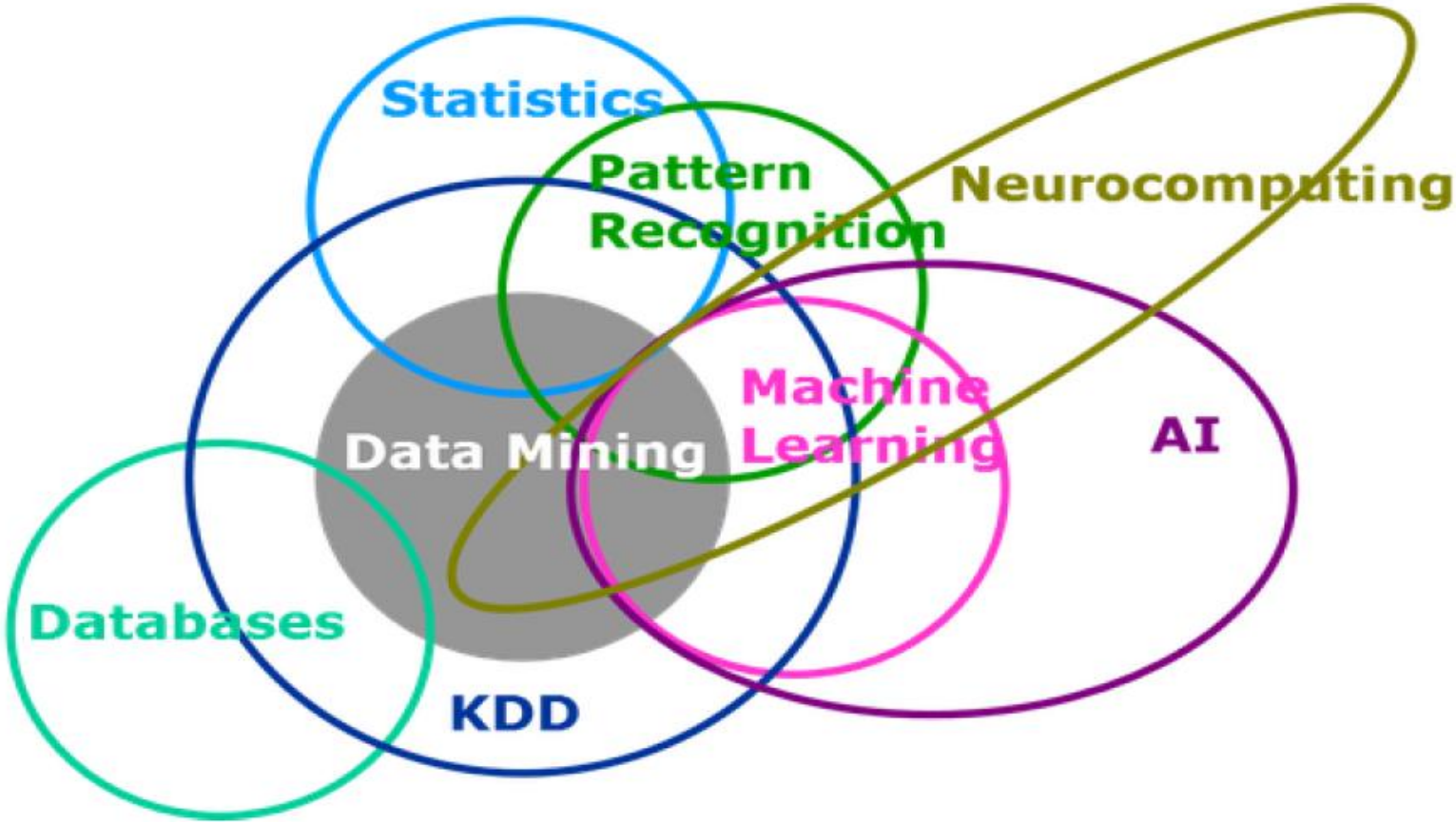
- If you doit right, the program works for new cases as well as the ones we trained it on.

- If the data changes, the program can change too by training on the new data

Massive amounts of computation are now cheaper than paying someone to write a task-specific program.

Machine Learning

"Field of study that gives computers the ability to learn without being explicitly programmed".
Arthur Samuel, 1959



Machine Learning

Tom Mitchell (1998) provides a more modern definition:

“A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E.” Example : I will make a simple example to understand better .

Machine Learning

Example:

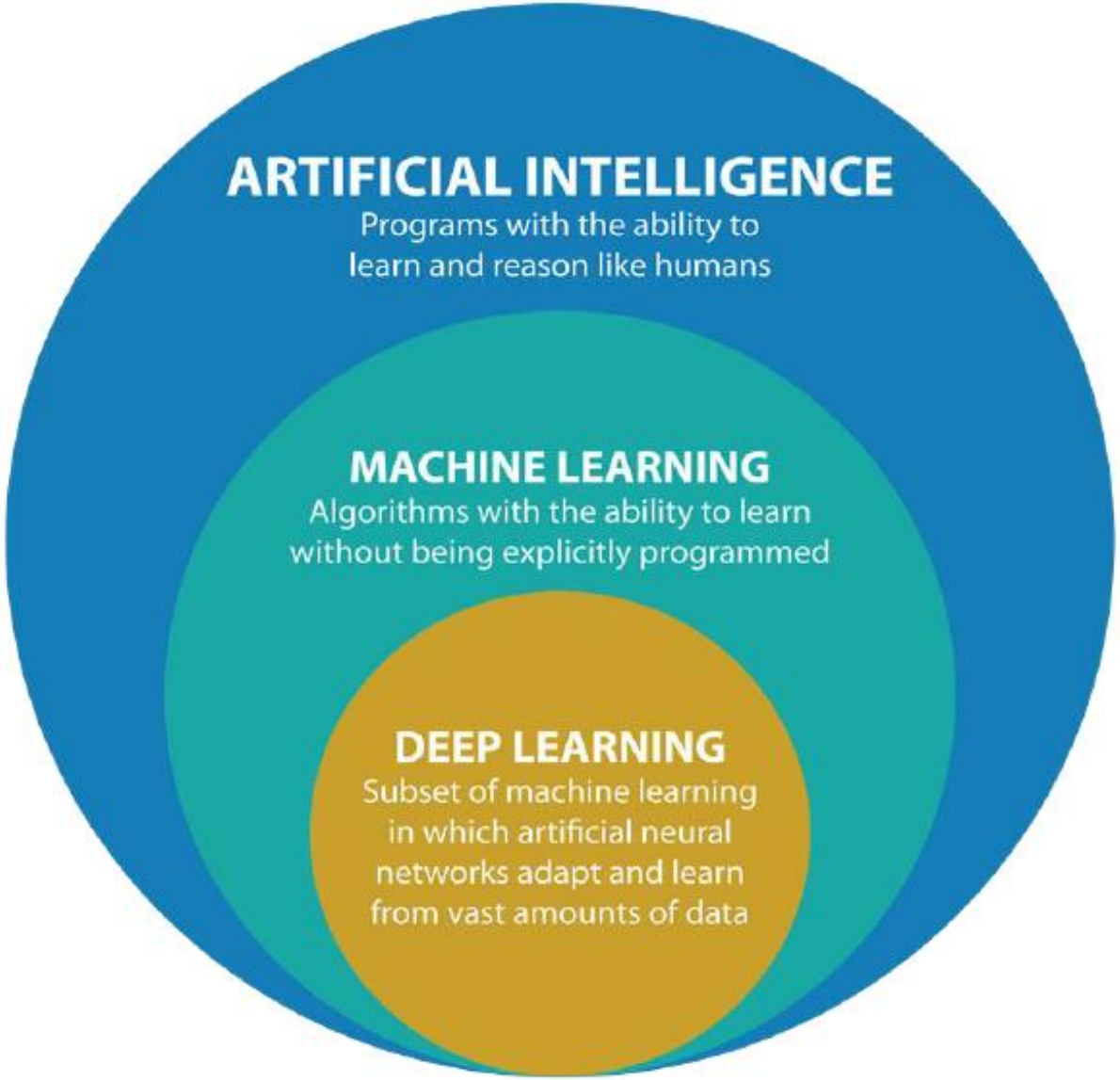
Suppose your email program watches which emails you do or do not mark as spam, and based on that learn show to better filter spam. What is the task T in this setting?

Classifying emails as spam or not spam.(Task T)

Watching you label emails as spam or not spam.(Experience E)

The number (or fraction) of emails correctly classified as spam / not spam.
(Performance measure P)

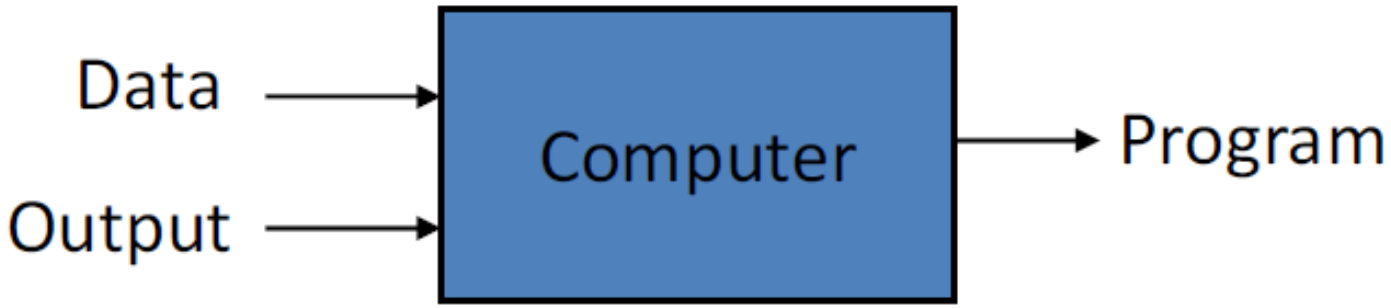
Machine Learning



Machine Learning

Traditional Programming

Machine Learning



Machine Learning

ML in a Nutshell

- Tens of thousands of machine learning algorithms
- Hundreds new every year
- Every machine learning algorithm has three components:
  - Representation
  - Evaluation
  - Optimization

Machine Learning

Representation

- Decision trees
- Sets of rules / Logic programs
- Instances
- Graphical models (Bayes/Markov nets)
- Neural networks
- Support vector machines
- Model ensembles
- Etc.

Machine Learning

Evaluation

- Accuracy
- Precision and recall
- Squared error
- Likelihood
- Posterior probability
- Cost / Utility
- Margin
- Entropy
- K-L divergence
- Etc.

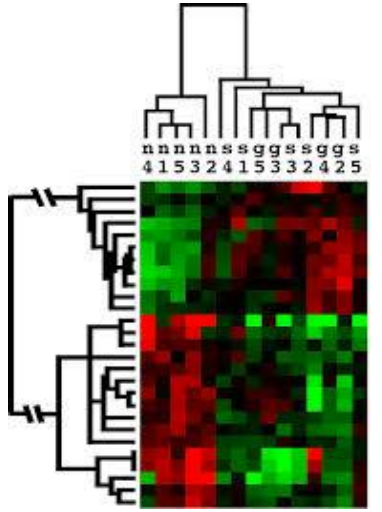
Machine Learning

Optimization

- Combinatorial optimization
  - E.g.: Greedy search
- Convex optimization
  - E.g.: Gradient descent
- Constrained optimization
  - E.g.: Linear programming

Machine Learning

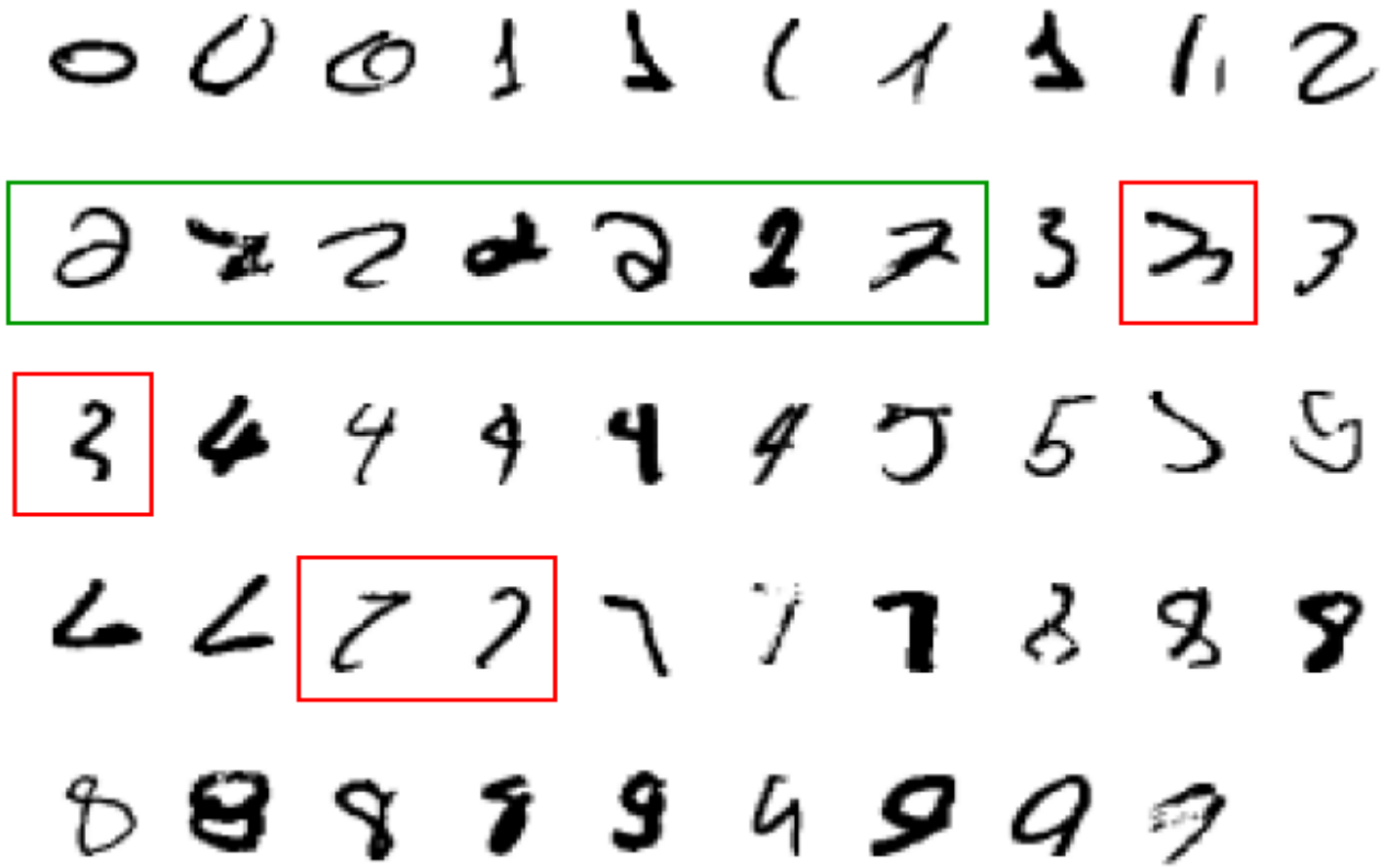
ML is used when:
- Human expertise does not exist (navigating on Mars)
- Humans can't explain their expertise (speech recognition)
- Models must be customized (personalized medicine)
- Models are based on huge amounts of data (genomics)



Learning isn't always useful:
- There is no need to "learn" to calculate payroll

Machine Learning

A classic example of a task that requires machine learning:
It is very hard to say what makes a 2



Slide credit: Geoffrey Hinton

Machine Learning

Some more examples of tasks that are best solved by using a learning algorithm

- Recognizing patterns:
  - Facial identities or facial expressions
  - Handwritten or spoken words
  - Medical images
- Generating patterns:
  - Generating images or motion sequences
- Recognizing anomalies:
  - Unusual credit card transactions
  - Unusual patterns of sensor readings in a nuclear power plant
- Prediction:
  - Future stock prices or currency exchange rates

Machine Learning

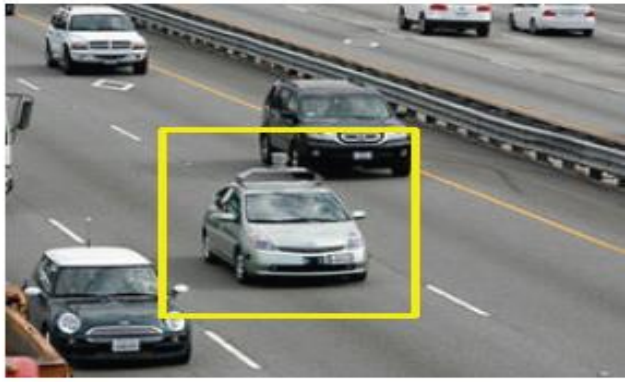
Sample Applications

- Web search
- Computational biology
- Finance
- Healthcare
- Agriculture
- E-commerce
- Space exploration
- Robotics
- Information extraction
- Social networks
- Debugging software
- [Your favorite area]

Machine Learning

State of the Art Applications of Machine Learning

Autonomous Cars



- Nevada made it legal for autonomous cars to drive on roads in June 2011
- As of 2013, four states (Nevada, Florida, California, and Michigan) have legalized autonomous cars

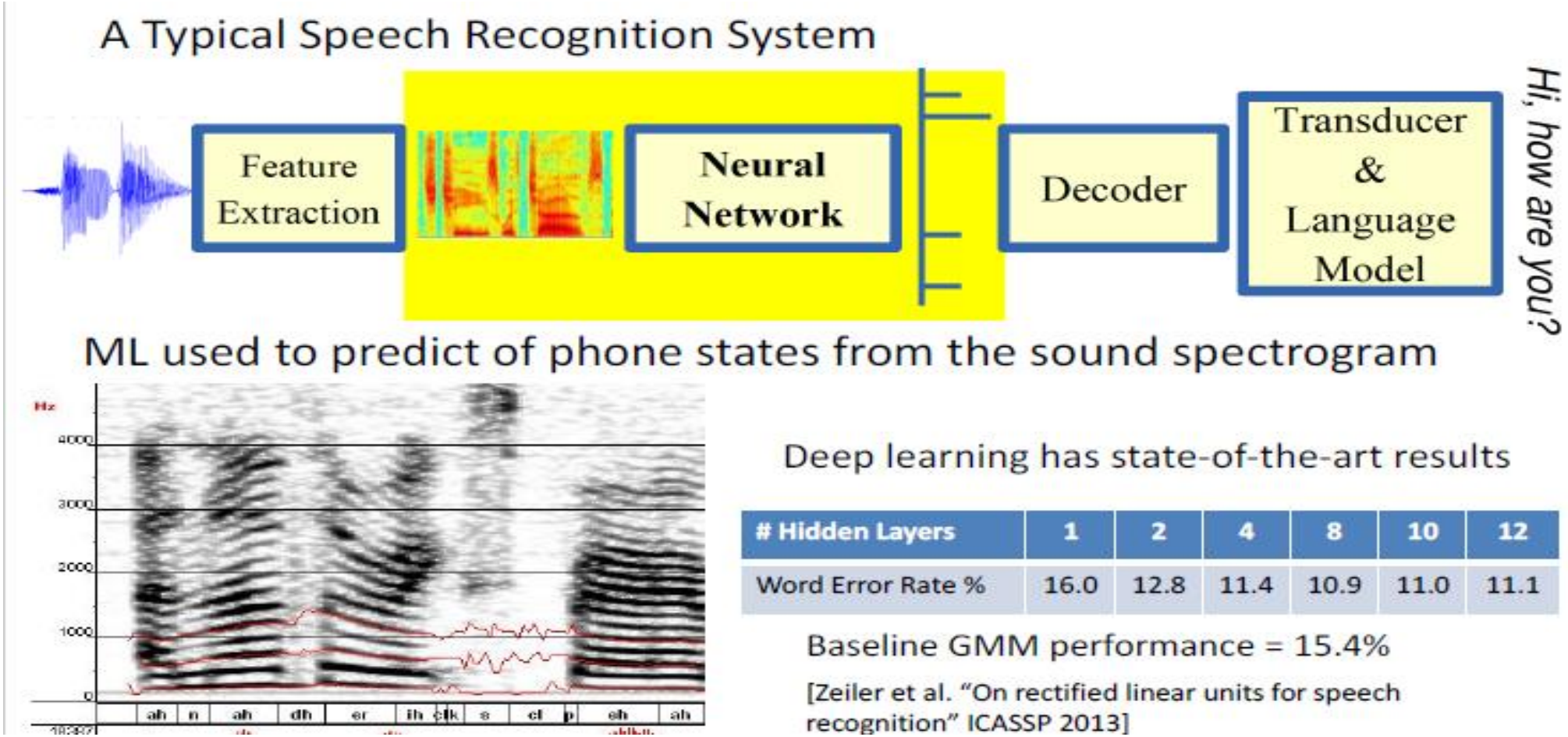
Penn's Autonomous Car →
(Ben Franklin Racing Team)

Machine Learning

State of the Art Applications of Machine Learning

Machine Learning

Machine Learning in Automatic Speech Recognition



Deep learning has state-of-the-art results

# Hidden Layers	1	2	4	8	10	12
Word Error Rate %	16.0	12.8	11.4	10.9	11.0	11.1

Baseline GMM performance = 15.4%

[Zeiler et al. "On rectified linear units for speech recognition" ICASSP 2013]

Conclusions

ML in Practice

- Understanding domain, prior knowledge, and goals
- Data integration, selection, cleaning, pre-processing, etc.
- Learning models
- Interpreting results
- Consolidating and deploying discovered knowledge
- Loop