INTRODUCTION TO ARTIFICIAL INTELLIGENCE

ECE 57000, Fall 2021

CRN: 34846

Matthews Hall 210

Instructor: David I. Inouye

Website: https://www.davidinouye.com/course/ece57000-fall-2021/

WHAT IS ARTIFICIAL INTELLIGENCE?

- Merriam-Webster Dictionary
  - "a branch of computer science dealing with the **simulation of intelligent behavior** in computers"

- Oxford Dictionary
  - "the theory and development of computer systems able to perform tasks that **normally require human intelligence**, such as visual perception, speech recognition, decision-making, and translation between languages."

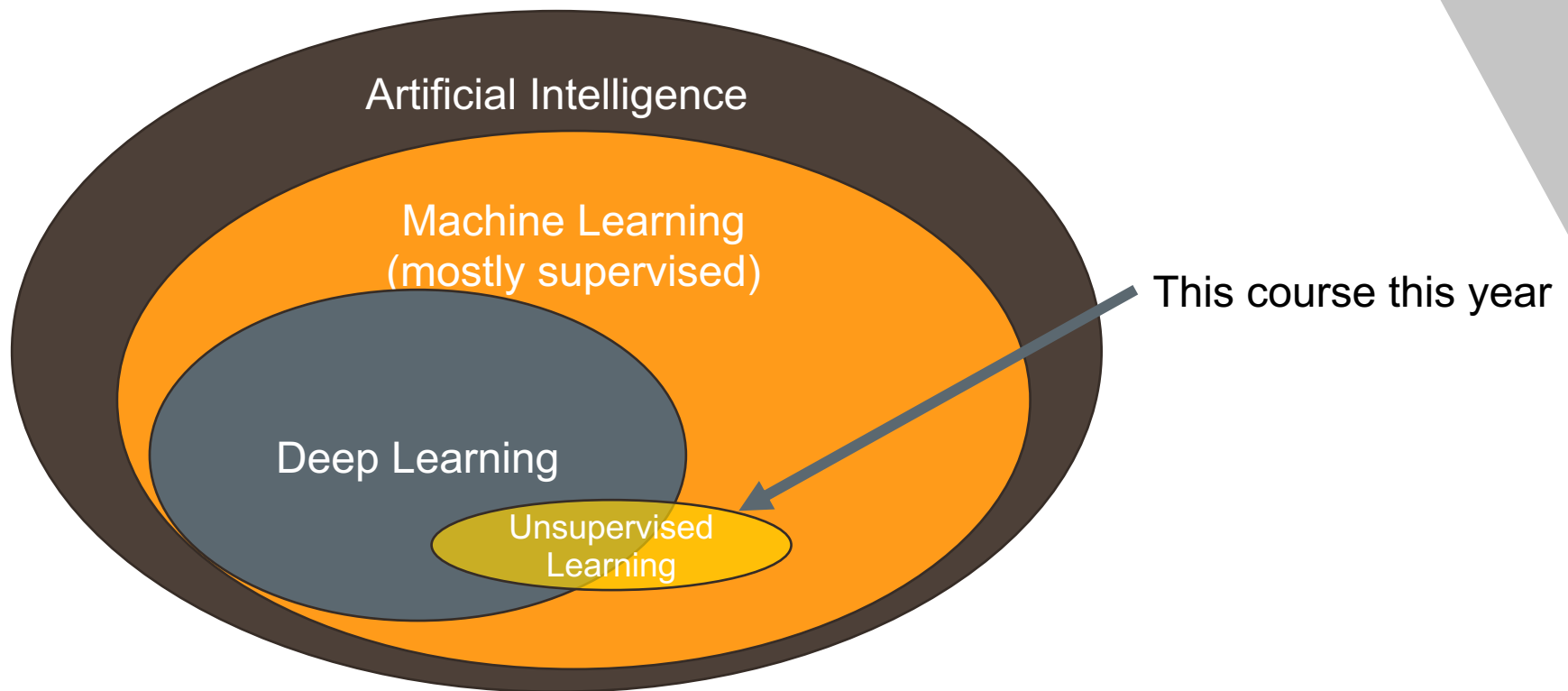# POSSIBLY A.I. IS A <u>MOVING TARGET</u>

- Are these A.I.?
  - Chess solvers
  - TurboTax
  - Chatbot
- What about these?
  - Speech recognition
  - Face recognition
  - Personalized recommendations
  - Self-driving cars
- "AI is anything that humans can do that computers cannot **<u>yet</u>** do."

A MORE PRAGMATIC DEFINITION

"AI is that which appears in academic conferences on AI" *

* From slides by Prof. Zico Kolter at CMU:
http://www.cs.cmu.edu/~./15780/slides/intro.pdf)

A.I. IS A VERY BROAD FIELD

Artificial Intelligence

Machine Learning
(mostly supervised)

Deep Learning

Unsupervised
Learning

This course this year

OTHER RELATED CLASSES

- ECE 695: Deep Learning (spring semester) by Prof. Kak and Prof. Bouman

- ECE 595: Introduction to Deep Learning by Prof. Aly El Gamal

- ECE 595: Machine Learning I (spring semester) by Prof. Stanley Chan

AGENDA

1. Announcements
   - Emergency preparedness
2. Syllabus
3. Logistics
4. (time-permitting) Defining AI

EMERGENCY PREPAREDNESS

As we begin this semester, I want to take a few minutes and discuss emergency preparedness. Purdue University is a very safe campus and there is a low probability that a serious incident will occur here at Purdue. However, just as we receive a "safety briefing" each time we get on an aircraft, we want to emphasize our emergency procedures for evacuation and shelter-in-place incidents. Our preparedness will be critical IF an unexpected event occurs!

EMERGENCY PREPAREDNESS

Emergency preparedness is your personal responsibility. Purdue University is actively preparing for natural disasters or human-caused incidents with the ultimate goal of maintaining a safe and secure campus. Let's review the following procedure

- For any emergency text or call 911.

- There are more than 300 Emergency Telephones (aka blue lights) throughout campus that connect directly to the Purdue Police Department (PUPD). If you feel threatened or need help, push the button and you will be connected right away.

- If we hear a fire alarm, we will immediately evacuate the building and proceed to the grassy area in front of **John Purdue's Grave Site**. Do not use the elevator.
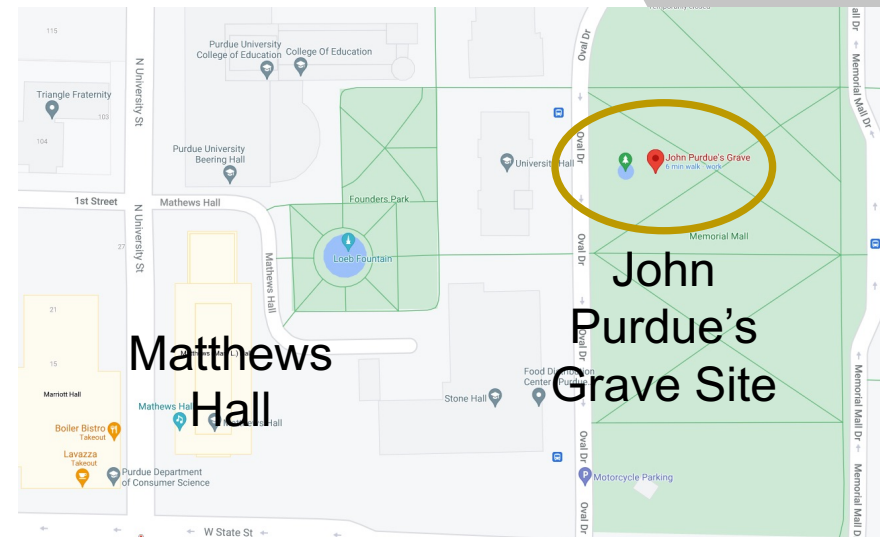
EMERGENCY PREPAREDNESS

- If we are notified of a Shelter in Place requirement for a **tornado warning, active shooter, or hazardous waste,** we will stop classroom or research activities and shelter in **this classroom (Room 210)**.

SYLLABUS!

All significant updates to the syllabus or course schedule will be posted on Piazza:

https://piazza.com/purdue/fall2020/ece57000inouyeall

See course website for syllabus and schedule:

https://www.davidinouye.com/course/ece57000-fall-2020/

LOGISTICS

- Brightspace
    - **First time: Click on links in Brightspace to connect Purdue account (demo)**
- The course website will have all other necessary links and content

NOW BACK TO AI...

A MORE PRAGMATIC DEFINITION

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http://www.cs.cmu.edu/~./15780/slides/intro.pdf)

NOT "MOVIE" A.I.

C-3PO and R2D2 in Star Wars.

*The rogue A.I. HAL9000 from the movie 2001: A Space Odyssey.*

Skynet from Terminator.

COMPUTERS DON'T "THINK" LIKE WE DO

[[5.49e-04 7.15e-04 5.60e-03 1.35e-02 9.42e-03 1.65e-03 4.38e-04 8.92e-04]
[9.64e-04 3.83e-04 1.38e-02 1.55e-02 1.06e-02 1.59e-02 5.07e-03 8.71e-05]
[2.02e-05 3.83e-03 1.58e-02 2.87e-03 9.79e-04 1.18e-02 8.46e-03 7.81e-04]
[1.18e-04 4.64e-03 1.21e-02 9.45e-04 5.22e-04 8.41e-03 8.26e-03 7.74e-04]
[4.56e-04 5.57e-03 8.02e-03 6.18e-04 6.12e-04 9.62e-03 8.94e-03 6.82e-04]
[3.60e-04 4.44e-03 1.17e-02 6.02e-05 1.67e-03 1.27e-02 7.21e-03 1.29e-04]
[3.15e-04 2.36e-03 1.46e-02 5.44e-03 1.10e-02 1.21e-02 2.09e-04 1.61e-04]
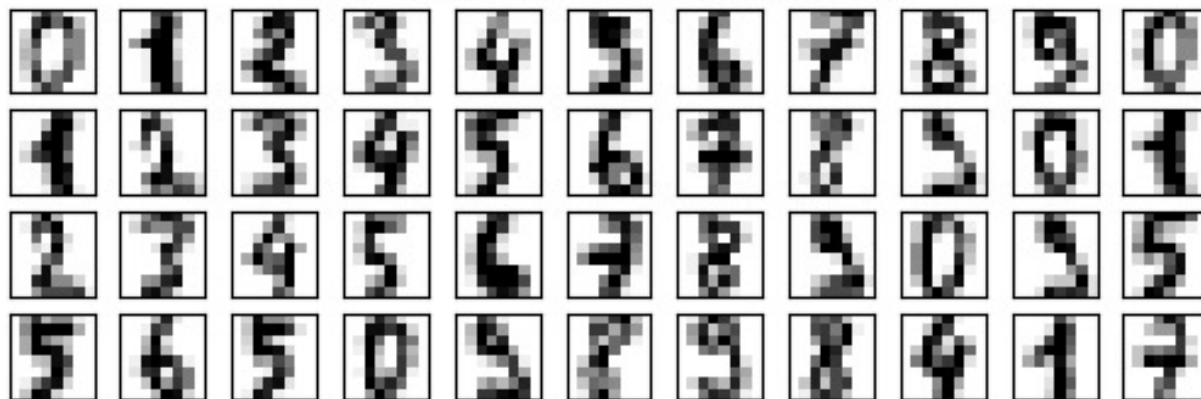[6.53e-04 2.53e-04 6.47e-03 1.32e-02 1.02e-02 1.10e-04 6.56e-04 1.38e-04]]

A matrix of numbers as the computer "sees".
Do you know what this matrix represents?

COMPUTERS DON'T "THINK" LIKE WE DO
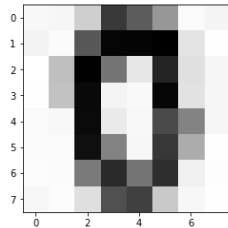
The same matrix of numbers displayed as an image.

Other examples from this dataset.
Do you know what the numbers represent now?

COMPUTERS DON'T "THINK" LIKE WE DO

$+ .007 \times$

$\mathbf{x}$

"panda"
57.7% confidence

$\text{sign}(\nabla_{\mathbf{x}} J(\boldsymbol{\theta}, \mathbf{x}, y))$

"nematode"
8.2% confidence

$=$

$\mathbf{x} +$
$\epsilon \text{sign}(\nabla_{\mathbf{x}} J(\boldsymbol{\theta}, \mathbf{x}, y))$
"gibbon"
99.3 % confidence

Real gibbon…

* From Explaining and Harnessing Adversarial Examples by Goodfellow et al.

NOR IS HUMAN IMITATION NECESSARILY THE GOAL

• Consider flight

Imitation

Understanding
+ Engineering
(Underlying
principles)

DARPA'S PERSPECTIVE ON AI

- First wave – Handcrafted Knowledge

- Second wave – Statistical Learning

- Third wave (future) – Contextual Adaptation

Excellent DARPA video (16 min) on AI (content above based on this):
https://www.youtube.com/watch?v=-O01G3tSYpU

1ST WAVE: HANDCRAFTED KNOWLEDGE

- Examples
  - Auto-scheduling systems
  - Chess
  - TurboTax
  - Simple medical diagnosis
- Good at
  - Logical reasoning from rule
- Bad at
  - Perceiving
  - Learning

Perceiving
Learning
Abstracting
Reasoning

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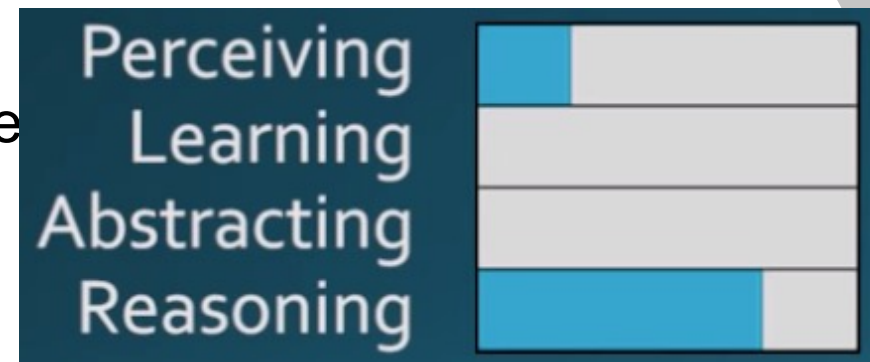
ONE KEY PROBLEM:
(FORMALLY) STATING WHY IS HARD
BUT LABELING IS EASY

- What is this a photo of?

- **<u>Why</u>** is this an image of a cat?
- Can you state a rule for all cats?

2ND WAVE: STATISTICAL LEARNING

- Examples
  - Voice/face recognition
  - Personalized recommendations

- Good at
  - Perceiving
  - Learning
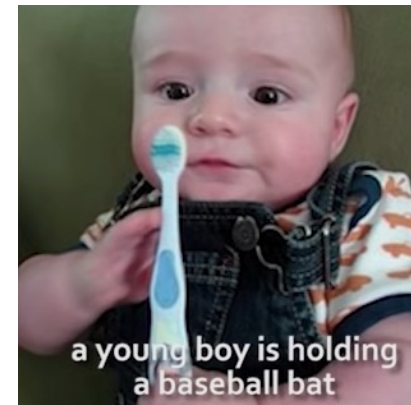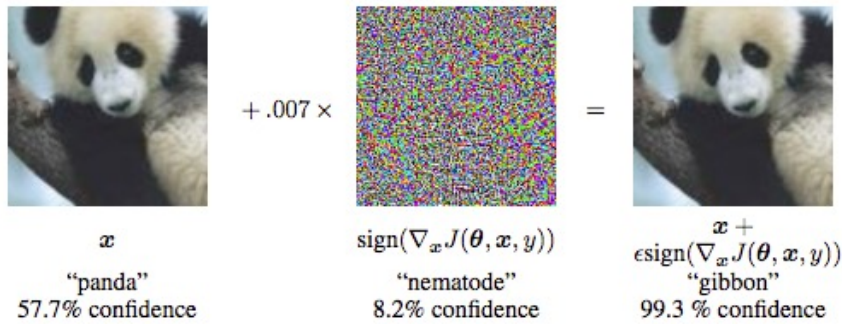
- Bad at
  - Logical reasoning
  - Robustness

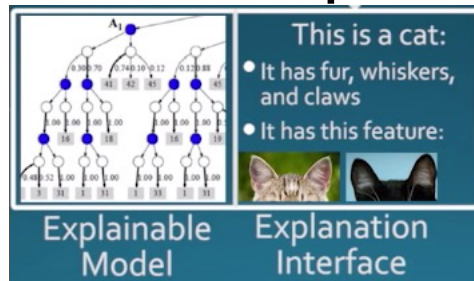Excellent DARPA video (16 min) on AI (content above based on this):
https://www.youtube.com/watch?v=-O01G3tSYpU

KEY PROBLEMS WITH 2ND WAVE

• Lack of robustness / fragile systems

$$+ .007 \times$$

x
"panda"
57.7% confidence

$\text{sign}(\nabla_x J(\theta, x, y))$
"nematode"
8.2% confidence

$x + \epsilon\, \text{sign}(\nabla_x J(\theta, x, y))$
"gibbon"
99.3 % confidence

a young boy is holding
a baseball bat

• Lack of explanations

This is a cat:
• It has fur, whiskers, and claws
• It has this feature:

Explainable
Model

Explanation
Interface

I understand why
I understand why not
I know when you'll succeed
I know when you'll fail
I know when to trust you

Excellent DARPA video (16 min) on AI (content above from): https://www.youtube.com/watch?v=-O01G3tSYpU

3RD WAVE (FUTURE): CONTEXTUAL ADAPTATION

- Combination of previous two waves
- System will construct **explanatory models**
  - Causation
  - Some abstraction
  - Explainable

- Examples
  - Incorporate handwriting knowledge for recognizing new characters
  - ? - (Maybe you can work on this)

- Good at
  - Perceiving
  - Learning
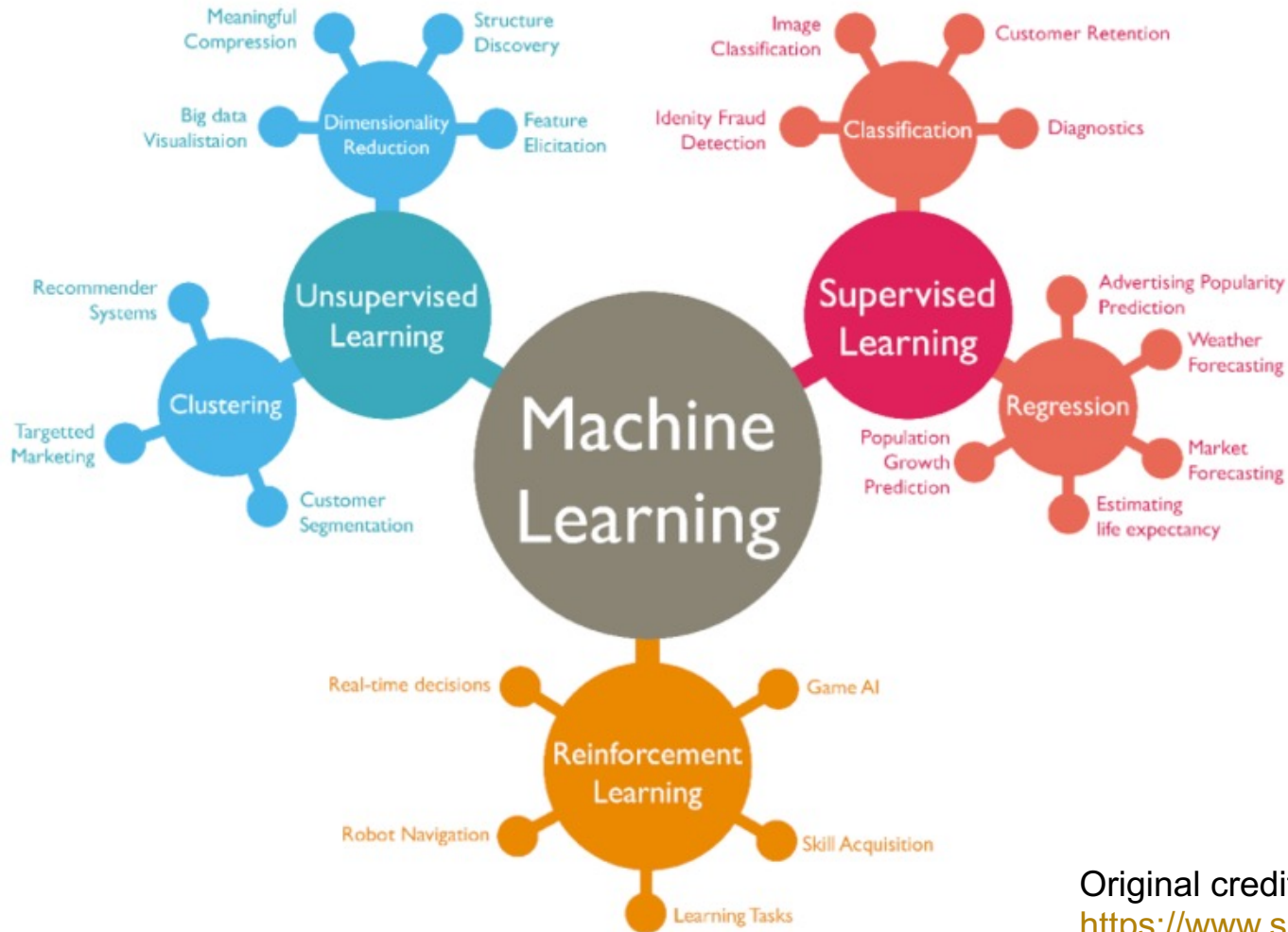 - Reasoning

- Slightly better at
  - Abstracting

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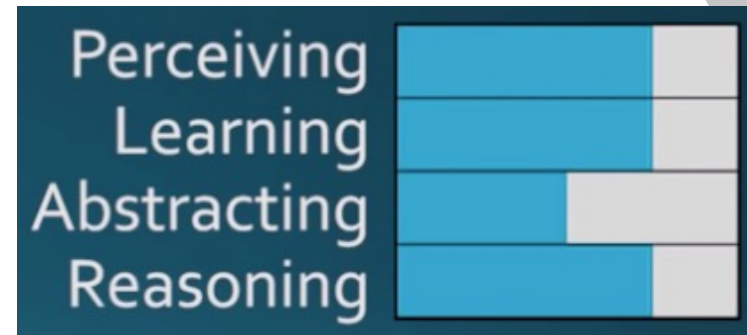
MACHINE LEARNING IN AI

- ML itself
  - Models
  - Algorithms
  - Theory

- Or as tool for other AI applications
  - Natural language processing
  - Computer vision
  - Robotics

INCOMPLETE TAXONOMY OF ML

WHY UNSUPERVISED LEARNING?

- **Labeling data is expensive (Supervised)**

- **Gathering raw data is cheap (Unsupervised)**

- **Best will probably be a combination**

WHY UNSUPERVISED LEARNING? POSSIBLY FOR "COMMON SENSE"

- *"AI systems today do not possess <u>"common sense"</u>, which humans and animals acquire by observing the world, acting in it, and understanding the physical constraints of it. Some of us see <u>unsupervised learning</u> as the key towards machines with common sense."*

    - Yann LeCun, Head of Facebook AI, 2016.

QUESTIONS?