UCSF Health
Respiratory Care Service

The Future of Artificial Intelligence in Intensive Respiratory Care

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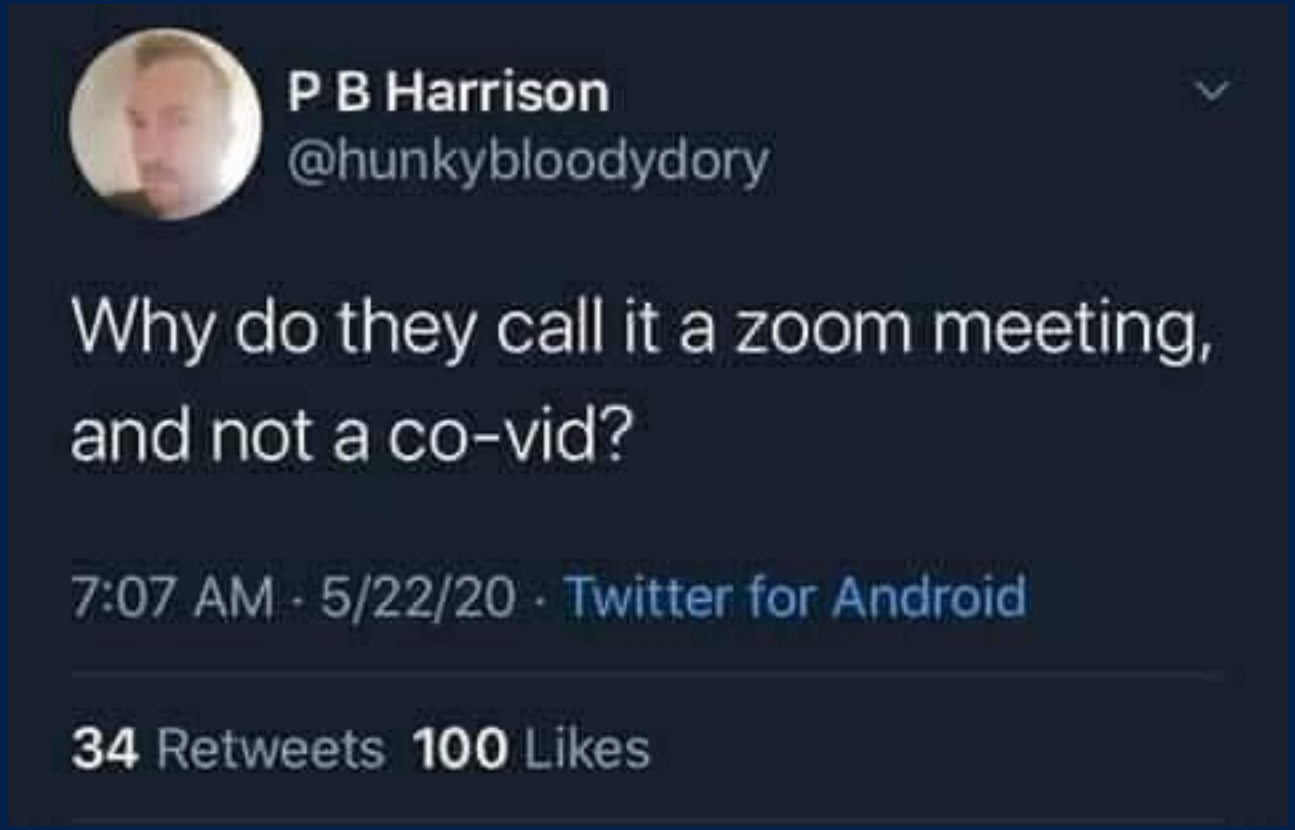
Respiratory Care Services
UCSF Health


WHY WAS THE
KING ONE FOOT TALL


P B Harrison
@hunkybloodydory
Why do they call it a zoom meeting, and not a co-vid?
7:07 AM · 5/22/20 · Twitter for Android
34 Retweets 100 Likes

22 years ago…

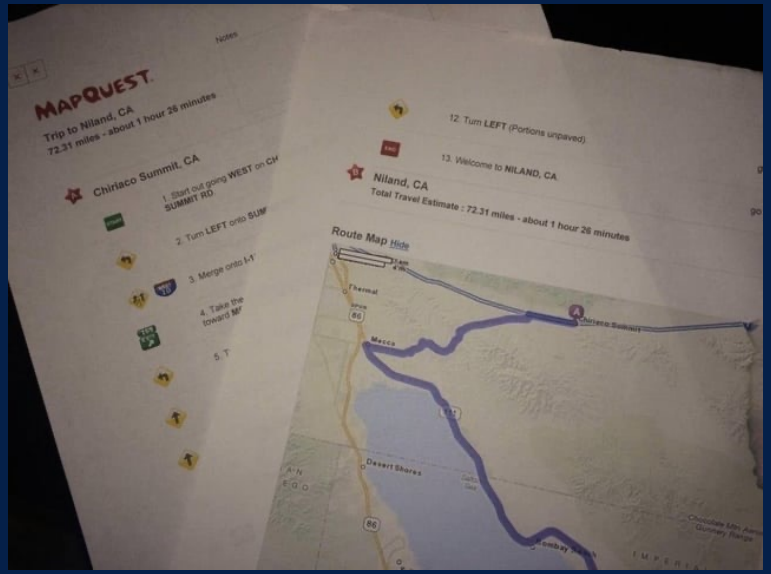
Today!

Manual transmission → 0-60 in 2.6s

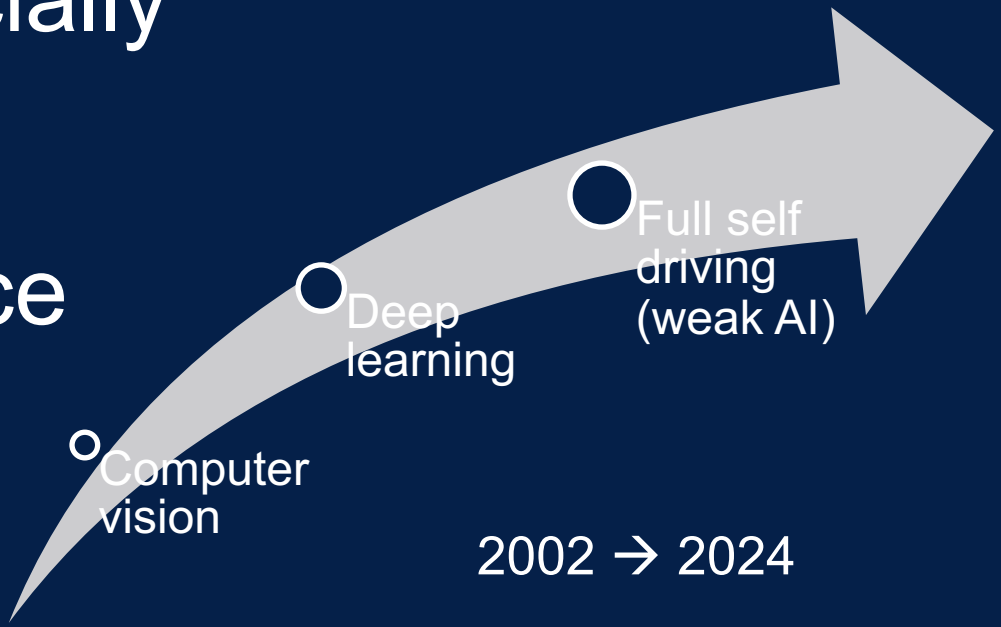
CD player → iTunes and YouTube…

…and on-board high-speed internet!

Printing out MapQuest → Full Self Driving



Commercially available artificial intelligence (AI)



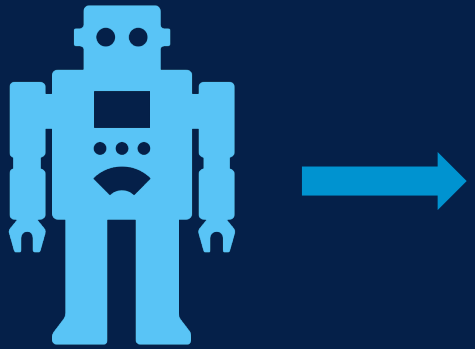
2002 → 2024

Mechanical ventilators

Today

How about in 22 years?

"Model V"



How may mechanical ventilation advance over the next 22 years?

Objectives

How can AI be used in Intensive Respiratory Care?

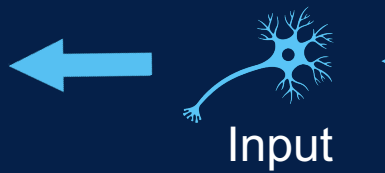
- What is AI and what is artificial general intelligence (AGI)
- Closed-loop mechanical ventilation
- Automated ventilator management
- Clinical decision support and the medical record
- Will AI replace my respiratory care practitioners (RCPs)?

Chapter 1
A Very Brief Introduction

Human intelligence

Driving

“Compute”

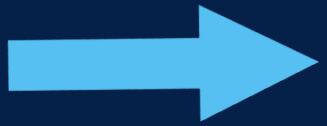


Input

Observes

Environment

We perform a multitude of tasks that allow us to drive safely



"Compute"

Tasks

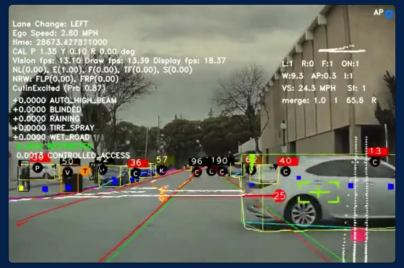
Steering → Lane Position

Braking → Follow Distance

Throttle → Acceleration

Artificial intelligence and full self-driving

"Compute"



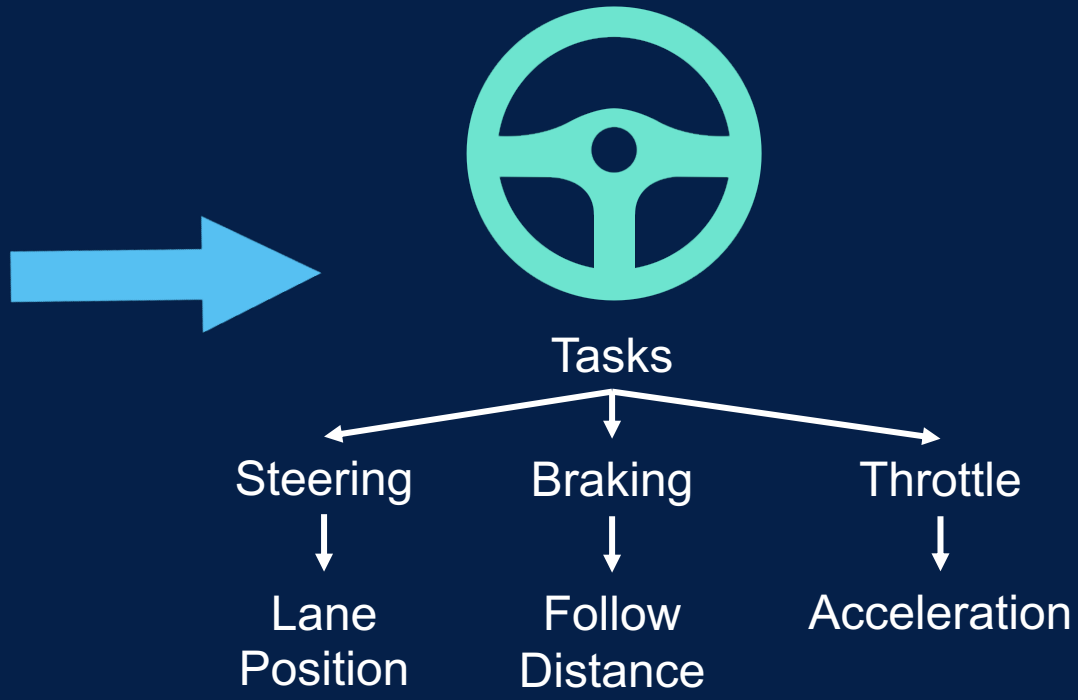
Input

Observes

Environment

Artificial intelligence and full self-driving

"Compute"



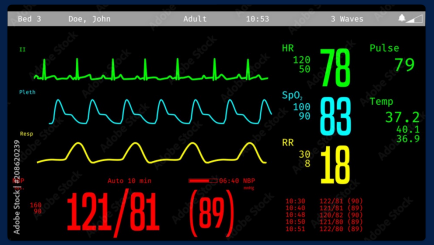
Human intelligence

Invasive mechanical ventilation (IMV) management

“Compute”

Input

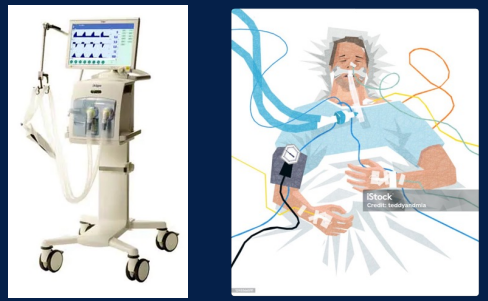
Observes



Environment

We perform a multitude of tasks when managing a patient receiving IMV

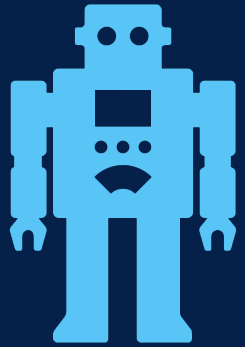
“Compute”



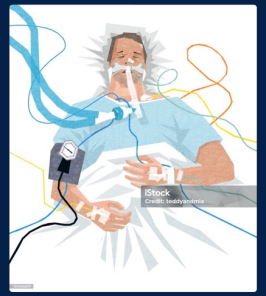
Tasks

- FiO2 Adjustment → Oxygenation
- RR → P_aCO_2 Control
- Airway → Wean/Extubate

How would this look with AI?



"Compute"



Tasks

- FiO2 Adjustment → Oxygenation
- RR → P_aCO_2 Control
- Airway → Wean/Extubate

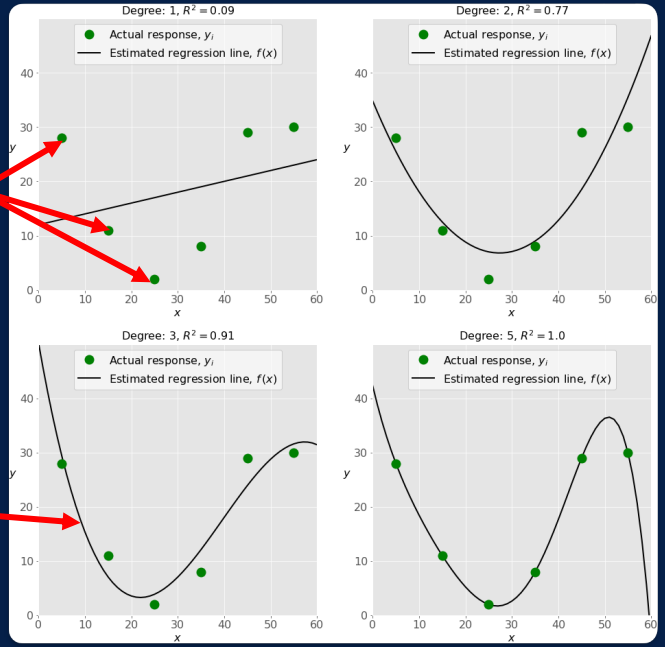
Chapter 2
Nuts and Bolts

“Modeling” is used to produce a prediction based on what can be observed

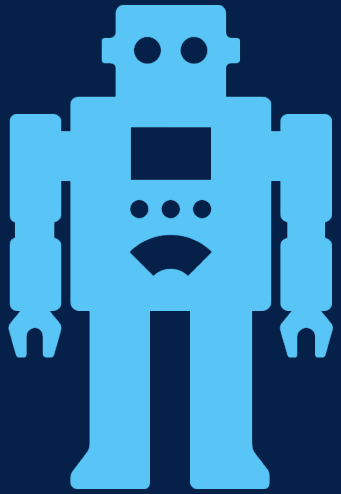
Data are collected, and a model is “fit”

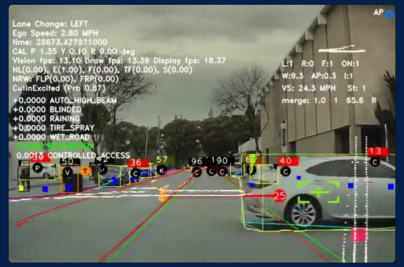
Real-world observations

Model



Training full self driving AI





Input

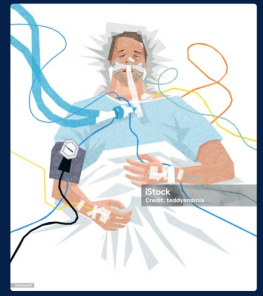
Observes

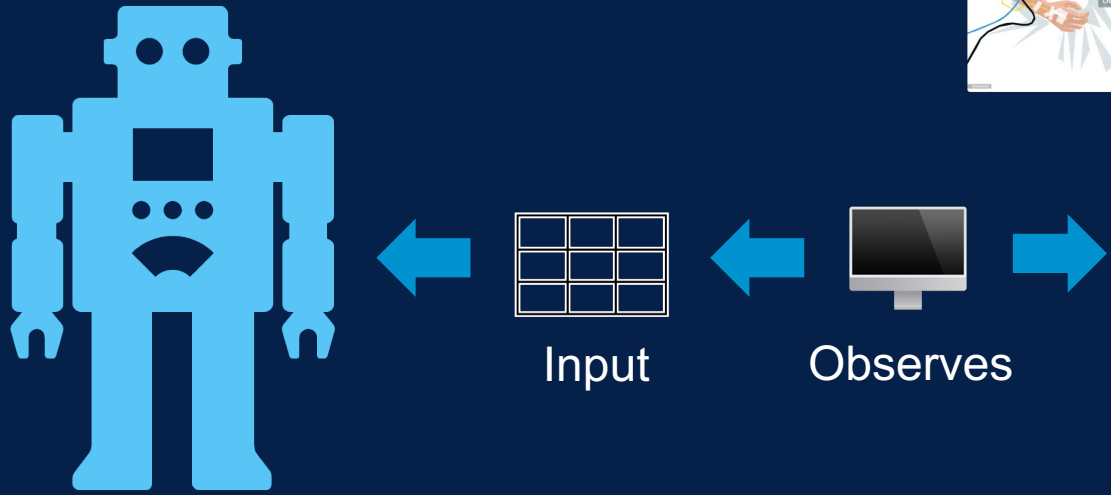
Waymo Training
January 2020
20 million miles*!

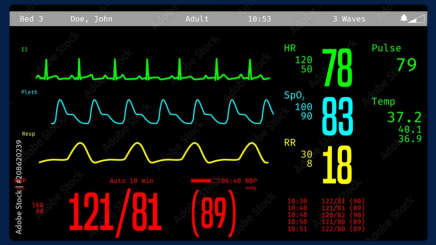
Environment

*Simulation City: Introducing Waymo's most advanced simulation system yet for autonomous driving. *Waymo* (https://waymo.com/blog/2021/07/simulation-city, Accessed May 8, 2024).

Training mechanical ventilation AI

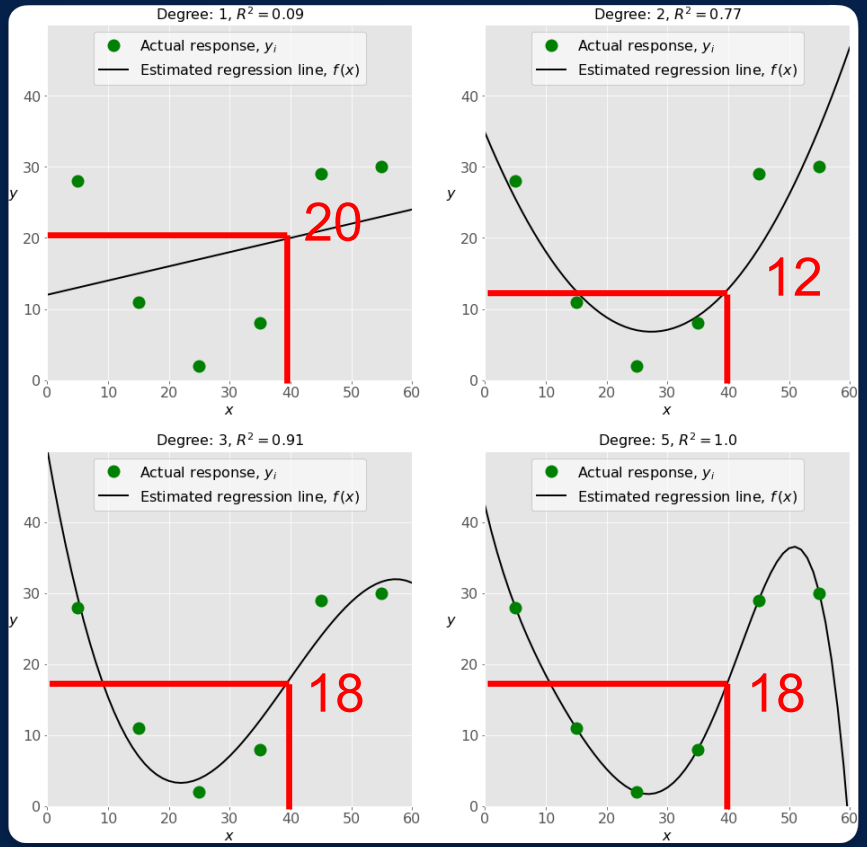






Environment

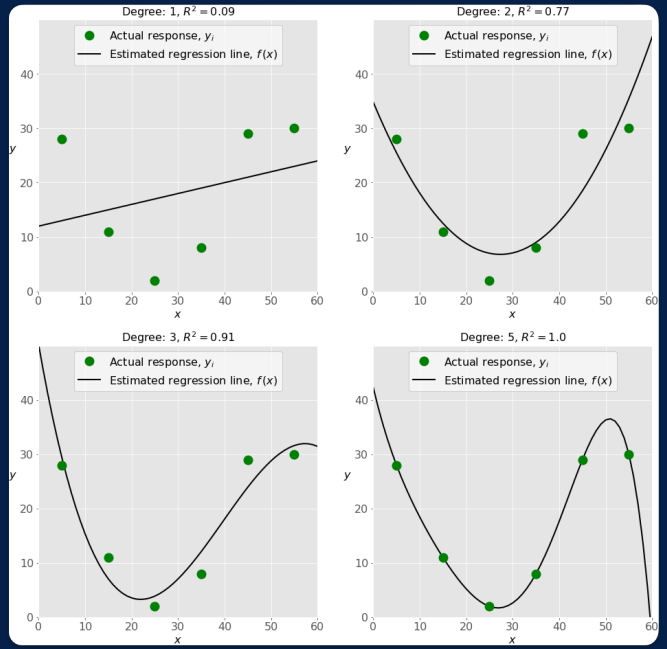
Prediction performance can vary with model tuning



But what happens when you compare the model to “new” data?

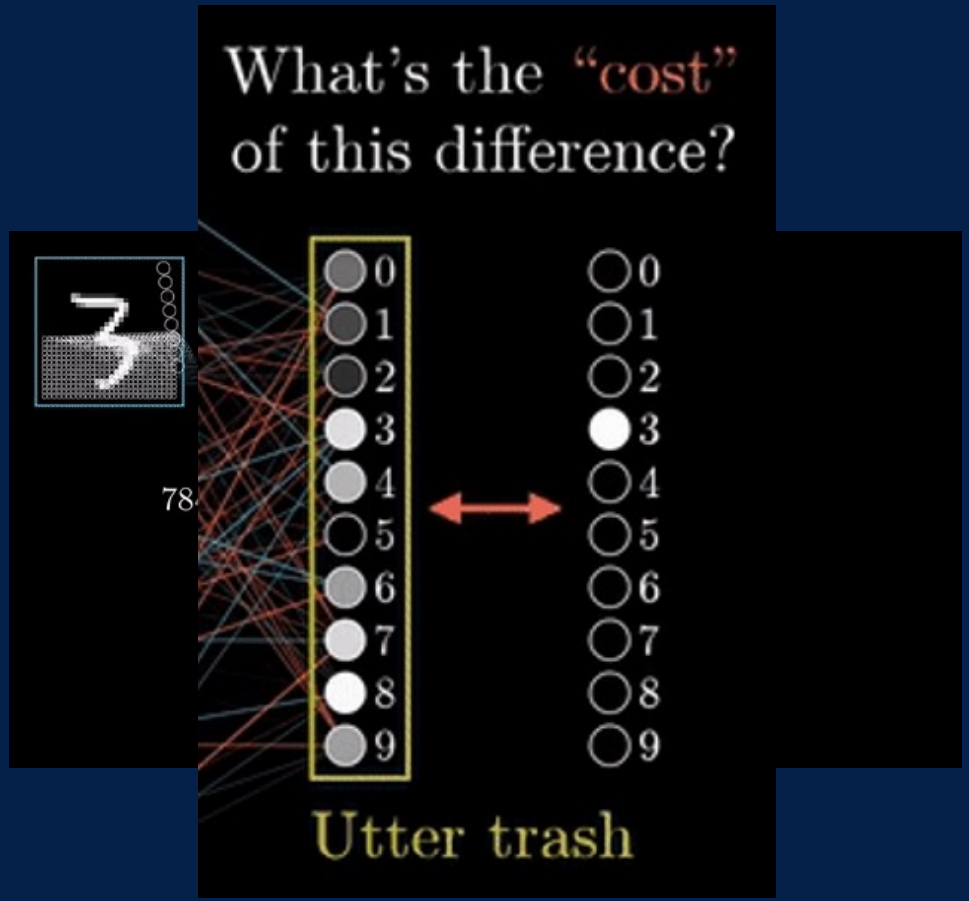
Statistical learning yield models that are highly interpretable

- Can be very accurate when assumptions are met
- Provide statistics!
  - Test statistics
  - P values
  - Confidence intervals
- Can therefore be “diagnosed”



Deep learning

- Model the function of the brain by using “neural networks”
- These collections of nodes are arranged in layers (100s!) and can make incredibly accurate predictions

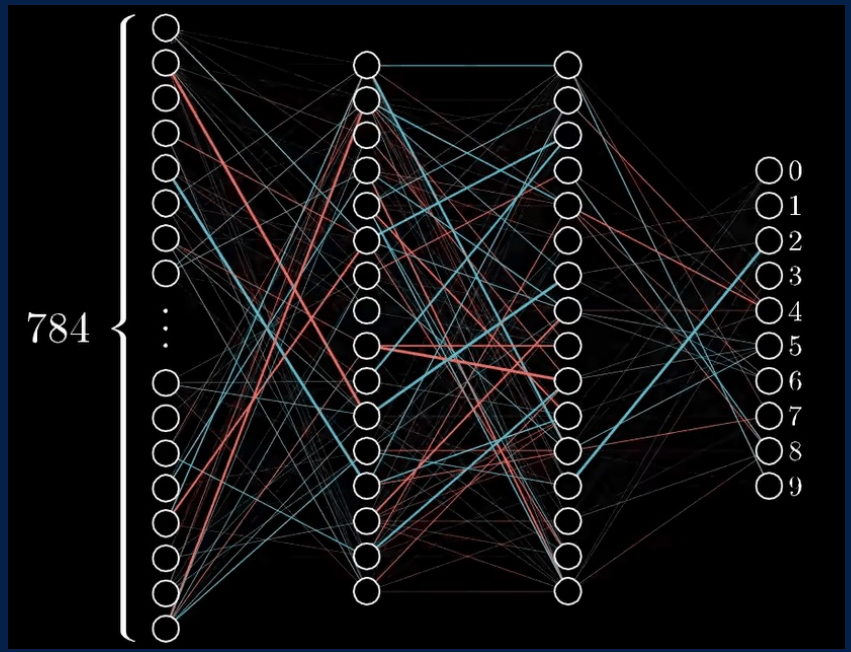


Jorgecardete. Backpropagation. *Medium* (https://pub.towardsai.net/backpropagation-2eeb25201095, Accessed May 8, 2024).

Deep learning

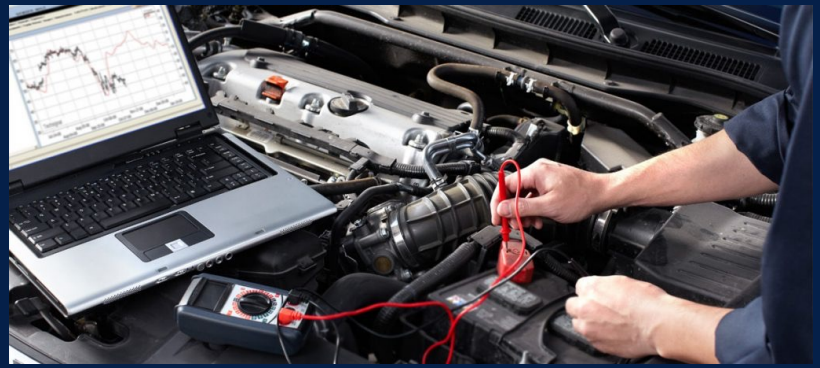
"Self learning" via backpropagation

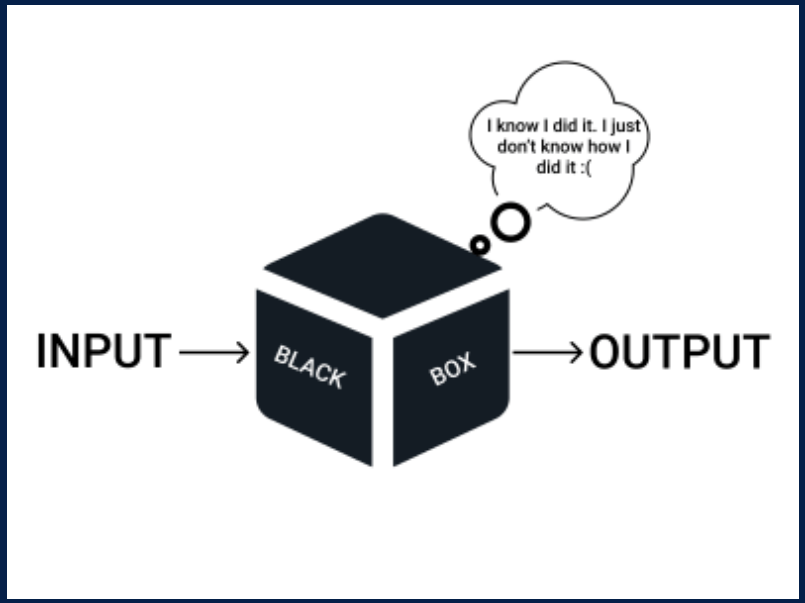
- The degree of "off-ness" (loss) is remembered
- Predictions are repeated until the loss is minimized



Jorgecardete. Backpropagation. *Medium* (https://pub.towardsai.net/backpropagation-2eeb25201095, Accessed May 8, 2024).

Key considerations for AI in medicine

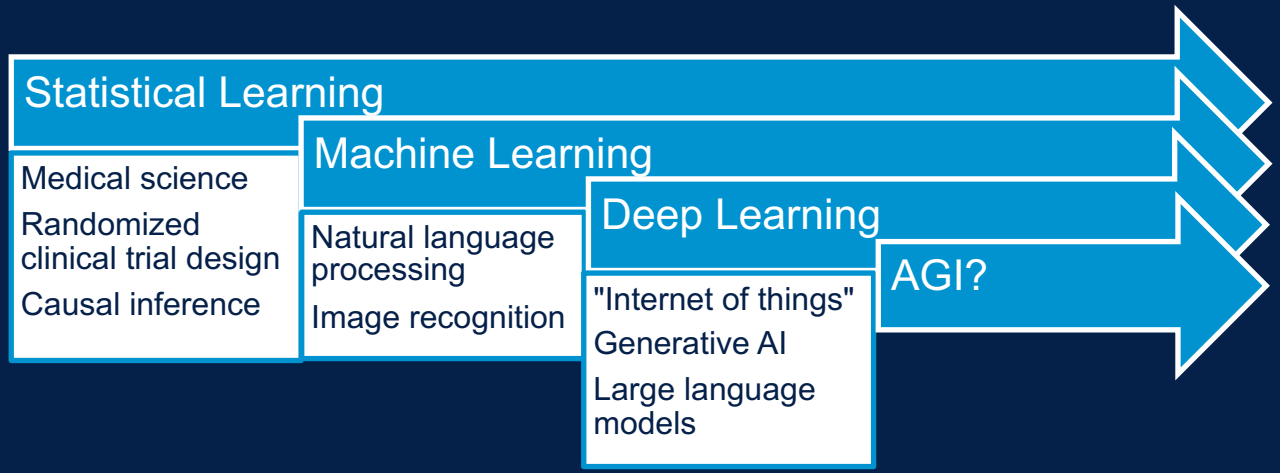


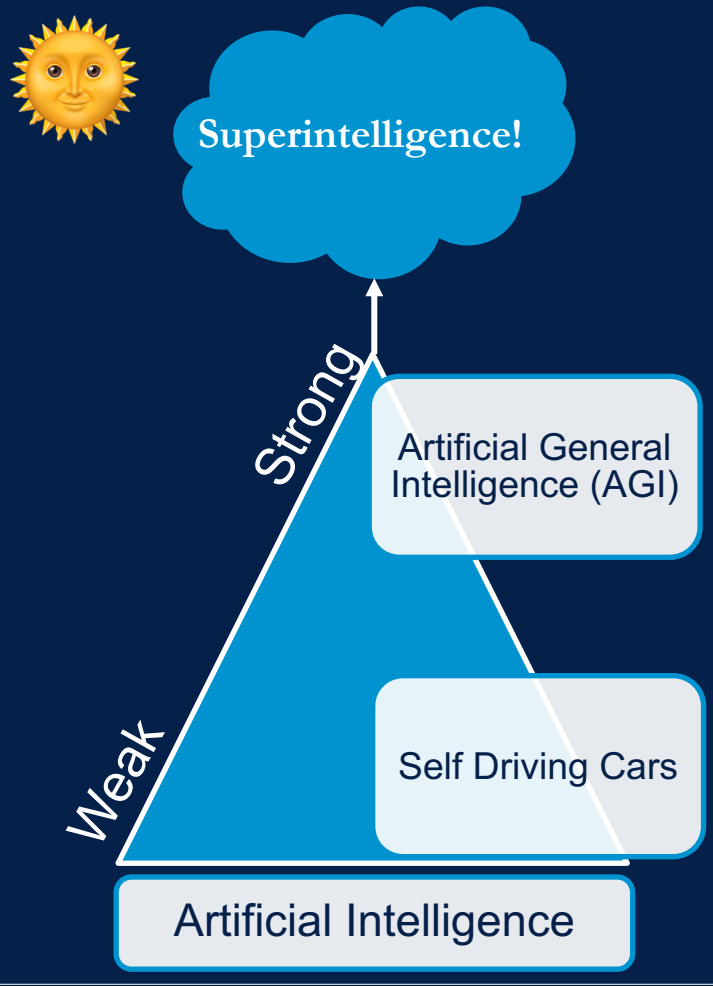


Statistical Models

ML/AI

Where does artificial general intelligence (AGI) fit in the grand scheme of things?




Superintelligence!
Strong
Weak
Artificial General Intelligence (AGI)
Self Driving Cars
Artificial Intelligence

Weak AI

Self driving cars and Waymo

Strong AI

AGI

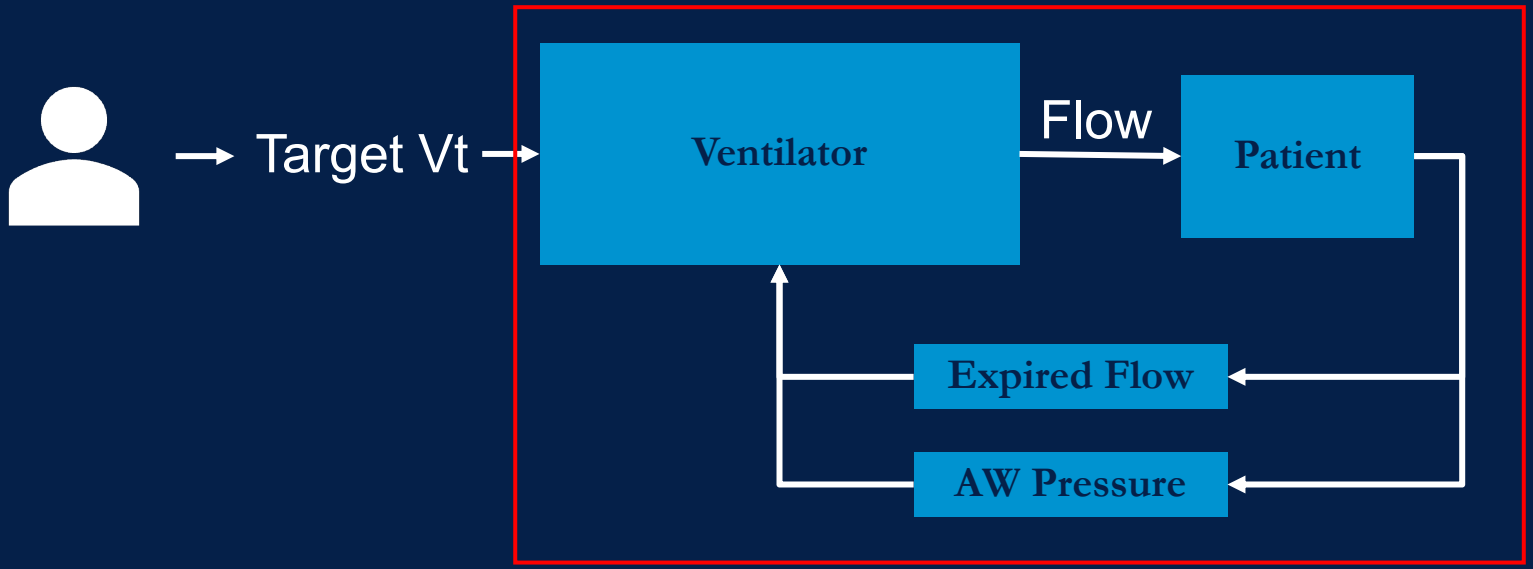
her
PNG Image · 986 KB

ex-machina
PNG Image · 922 KB

AGI ~~and~~ is the future

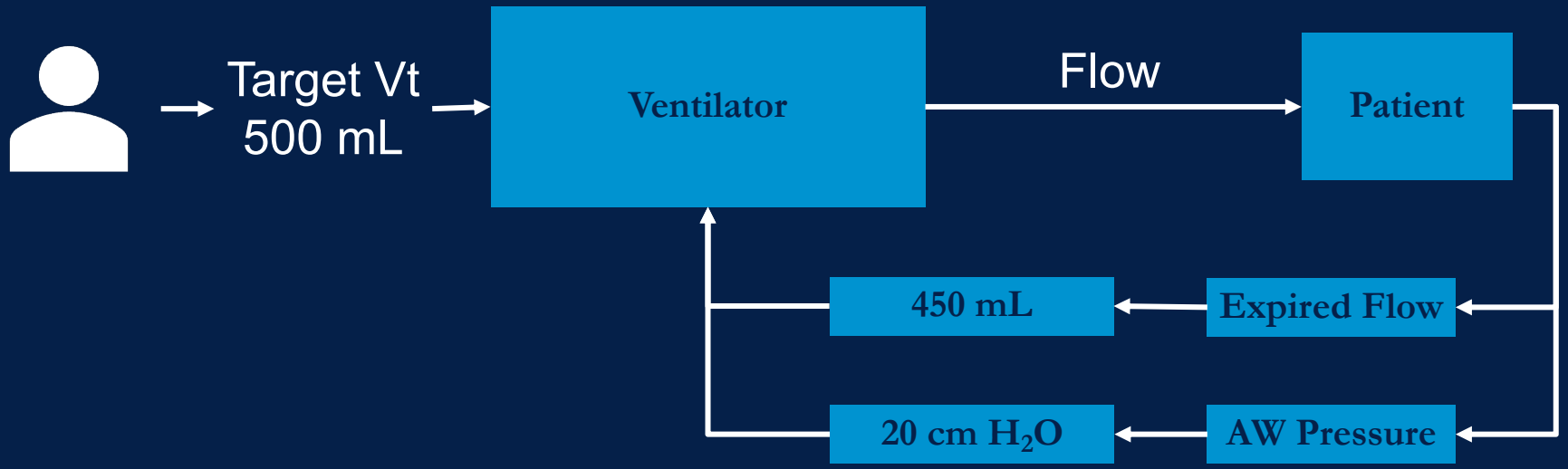
Chapter 3
Close the loop

An overview of closed loop mechanical ventilation (MV)



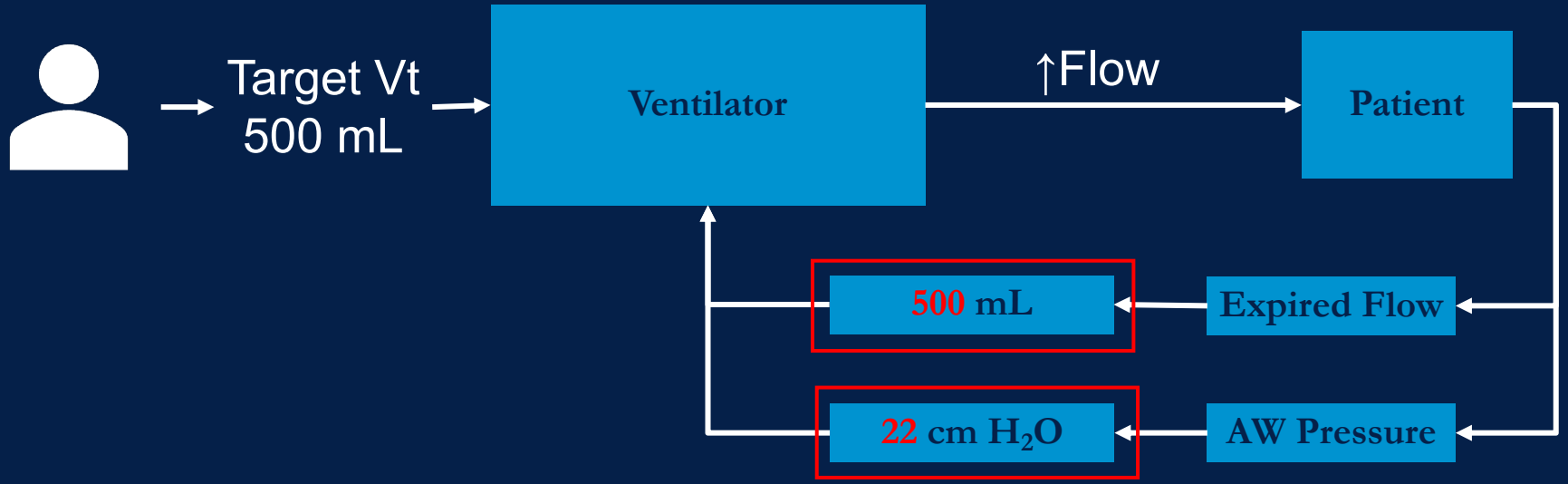
An overview of closed loop mechanical ventilation (MV)

Example: adaptive pressure control (PRVC, AutoFlow, etc)



An overview of closed loop mechanical ventilation (MV)

Example: adaptive pressure control (PRVC, AutoFlow, etc)



Closed loop MV **target** schemes

Servo

"Power steering"

Output follows input

Proportional Assist Ventilation, Neurally-Adjusted Ventilatory Assist

Adaptive

Ventilator adjusts set-points using programmed rules

May respond to varying patient conditions

Pressure Regulated Volume Control

Optimal

Vent adjusted targets

Adaptive support ventilation

Ventilator adjusts minute ventilation based on [vent] predicted MV demand and [vent] predicted Vd/Vt

PIP adjusted to target Vt; frequency

Expert rules embedded to minimize air trapping

Intelligent

Smartcare/PS

Vent auto-titrates patient through three steps

- Stabilization
- Inspiratory titration
- Weaning → "Consider extubation"

Robert L Chatburn, Eduardo Mireles-Cabodevila. Closed-Loop Control of Mechanical Ventilation: Description and Classification of Targeting Schemes. Respiratory Care 2011;56(1):85.

Physiological closed loop ventilation

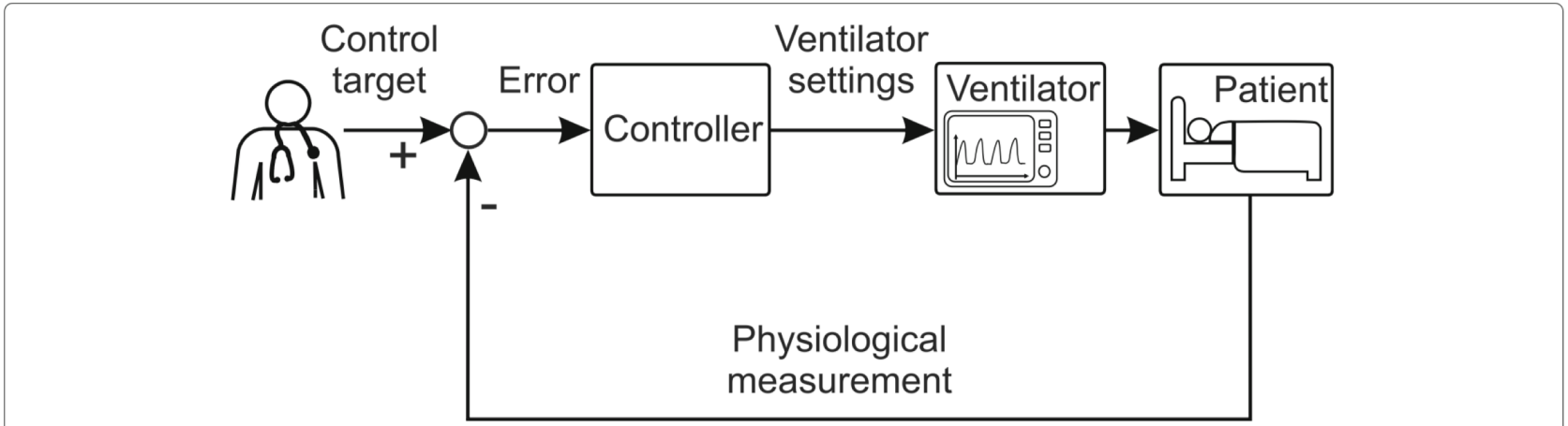
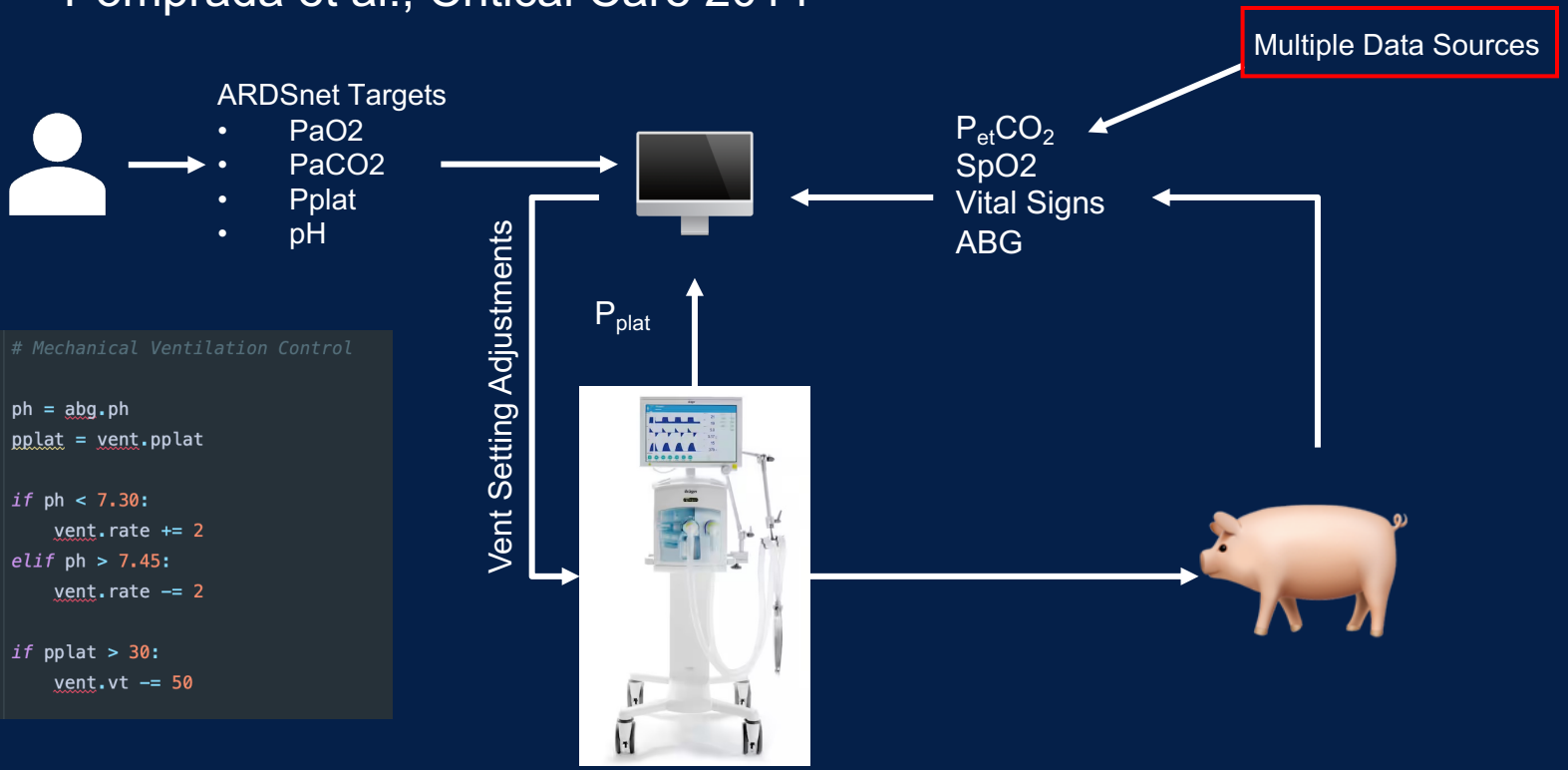


Fig. 2 Physiological closed-loop control for mechanical ventilation system

Platen P von, Pomprapa A, Lachmann B, Leonhardt S. The dawn of physiological closed-loop ventilation—a review. Critical Care 2020;24(1):121.

AUTO-ARDSnet

Pomprada et al., Critical Care 2014

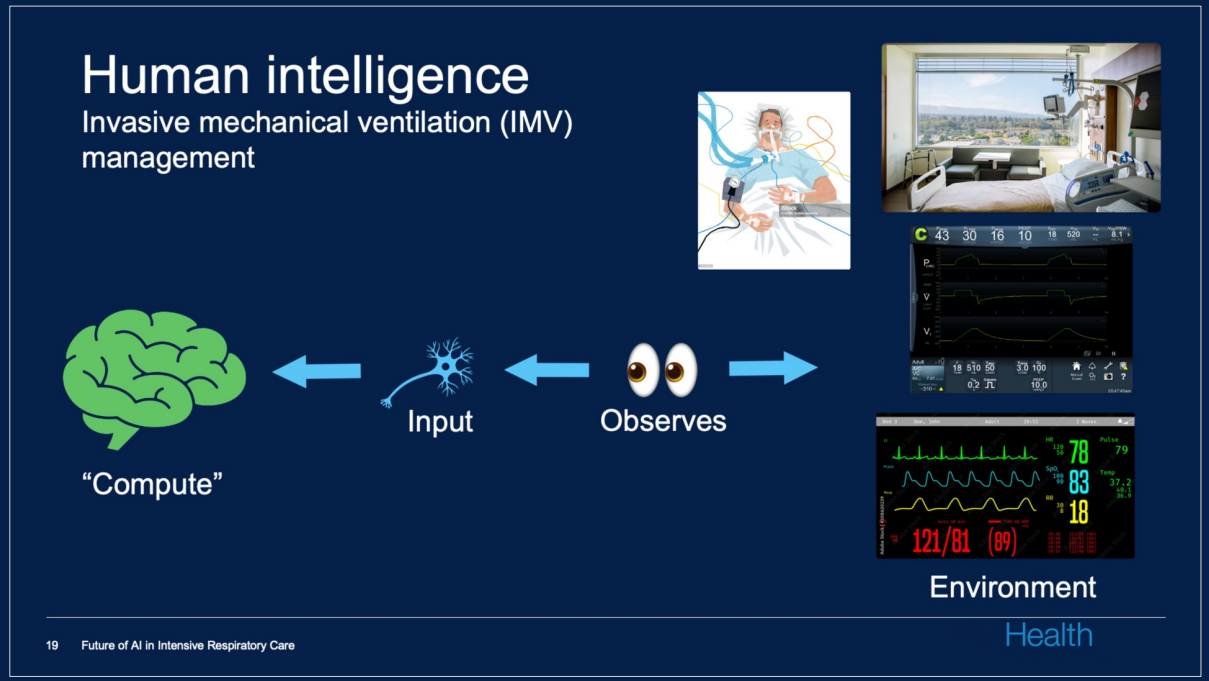



```
# Mechanical Ventilation Control

ph = abg.ph
pplat = vent.pplat

if ph < 7.30:
    vent.rate += 2
elif ph > 7.45:
    vent.rate -= 2

if pplat > 30:
    vent.vt -= 50
```

Increased automation(!)…but not AI?

We look beyond the vent when making clinical decisions

Recall the earlier slide…



- Clinical assessment
- Past medical history, history of present illness, clinical course
- *Our* clinical experience

Chapter 4
Beyond the vent

Full self-driving

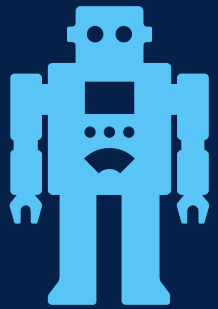
AI replaces the driver in self-driving cars

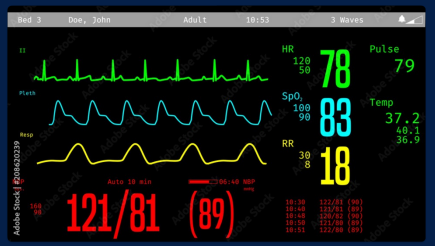
It can independently make *inferences* and perform the necessary tasks to safely maneuver the environment

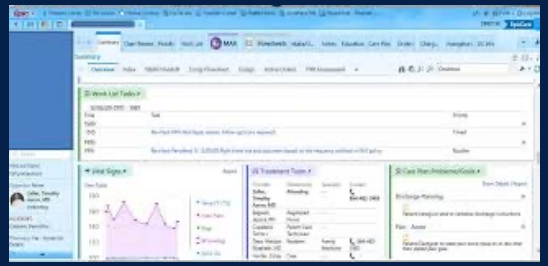
Mechanical ventilation

AI would need to receive the **proper data** that could allow it to make effective *inferences* to perform the necessary tasks to safely manage the ventilator

Incorporate the EMR!







Large language models (LLM) allow the use of unstructured clinical data

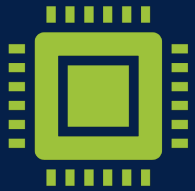
Clinical predictive models often use “structured” data from the electronic medical record (EMR)

Limited information in structured data and prone to missingness/erroneous data

LLMs can be used to make predictions from written text, solving many of the issues with structured data and potentially incorporating additional information

NYUTron

Jiang et al. Nature, 2023

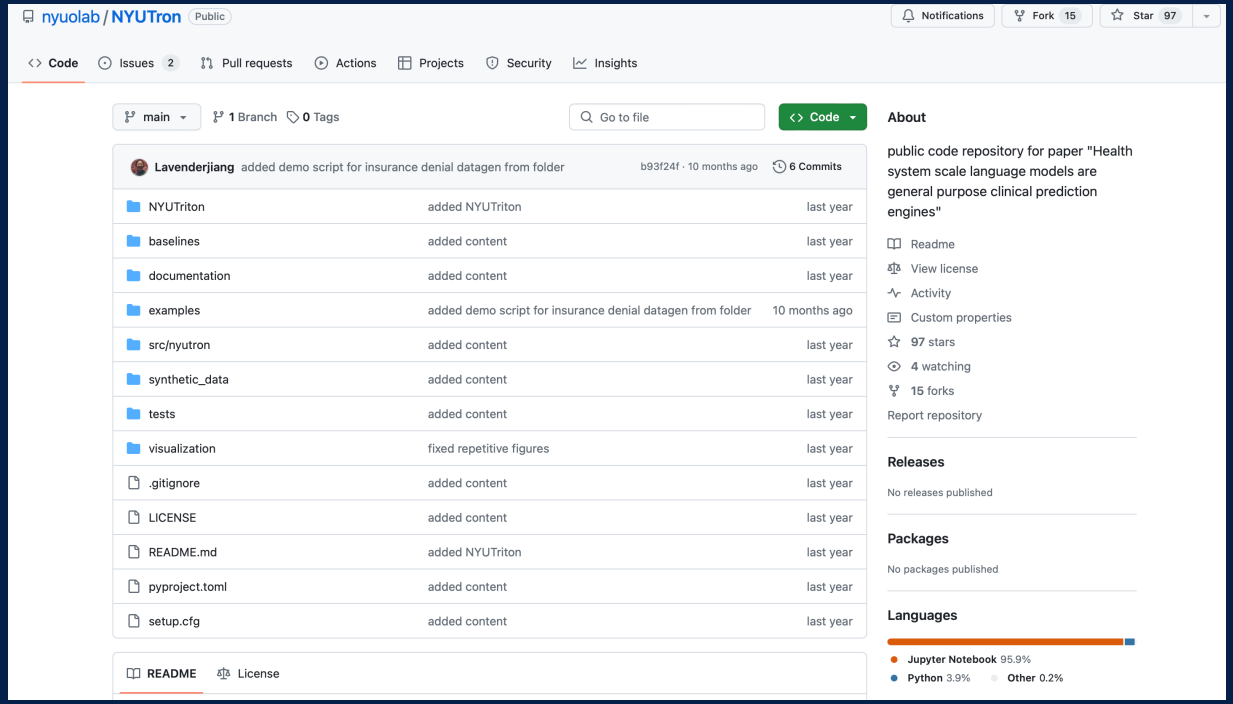


NYU researchers teamed with Nvidia to deploy a “NVIDIA NeMo Megatron framework” (LLM) on the EMR

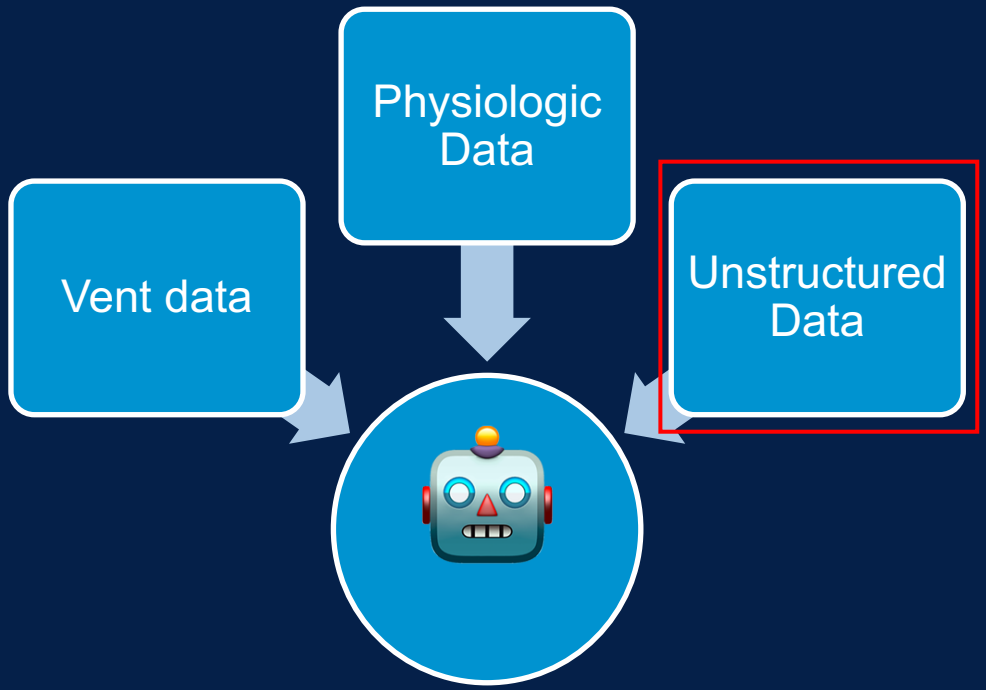
Required the use of specialized Nvidia data center infrastructure

Discharge summary → NYUTriton server → email to signing physician with prediction

All code available for reproduction!



NYUtron is a glimpse to what is possible

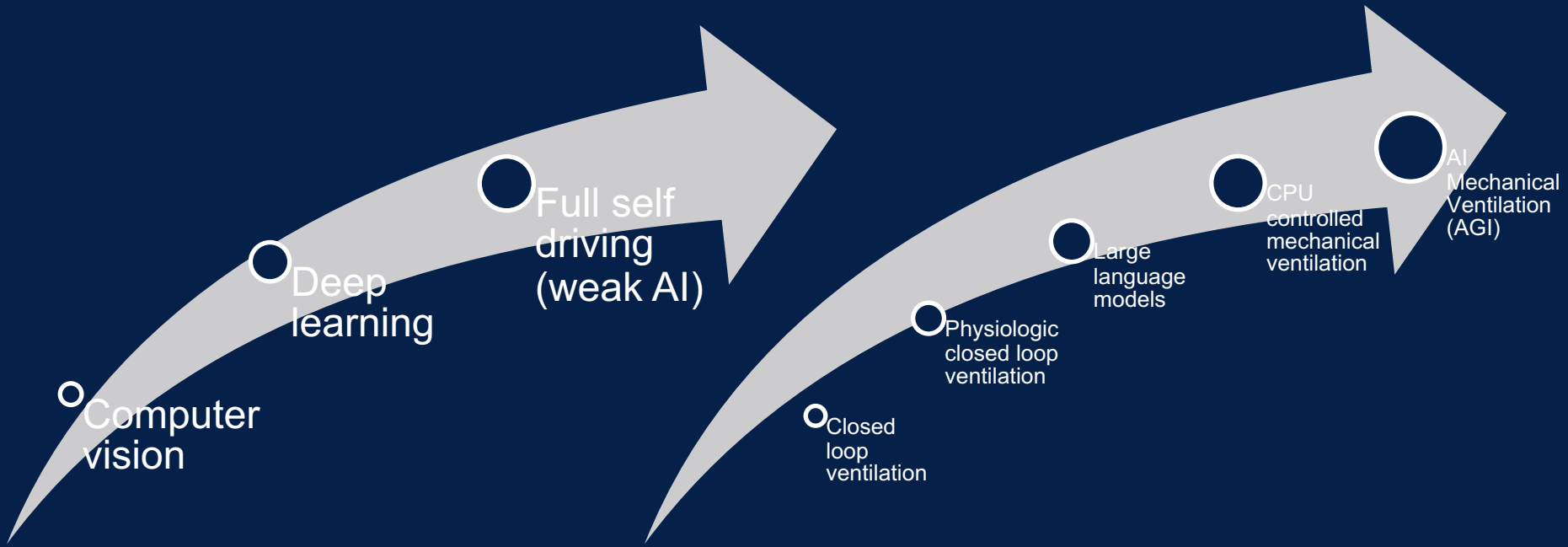


- Considerable hardware and software requirements
- The *WHY* must be demonstrated
- Randomized clinical trial is needed to show benefit of AI guided care

Chapter 5
The final chapter

Advancing to AI

What we learned with FSD → Mechanical Ventilation




evolving.ai
GENERATIVE AI WILL PROBABLY CREATE MORE JOBS THAN THERE ARE PEOPLE TO DO THEM BECAUSE OF JEVONS PARADOX.
GROQ CEO JONATHAN ROSS ON TRANSITIONING TO THE GENERATIVE AI AGE
SWIPE TO WATCH
Liked by paymandehdezi and others
evolving.ai 👀🗣️ Groq CEO Jonathan Ross says generative AI will create MORE JOBS than there are people to do them because of Jevons Paradox

```python
presentation_end = True


if presentation_end:
    print("The End! Thanks for attending!")
```

ation_end

enio_gpt35 × presentation ×

```
/Users/burnsgr/anaconda3/bin/python /Users/burnsgr/Documents/GitHub/RCS_Clarity/presentation.py
The End! Thanks for attending!
```