



Introduction to AI & ML

Application of Artificial Intelligence & Machine Learning for Precision Medicine
February 16, 2023

MIT
MATHEMATICS



Alan Edelman

with thanks to Chris Rackauckas

The JuliaLab@MIT

& JuliaHub Inc.

The screenshot shows the JuliaLab website homepage. At the top, the logo 'julia lab' is followed by the tagline 'Accelerating Computation through a marriage of Computer Science & Computational Science'. Navigation links include 'Home', 'News', 'Research/Grants', 'Project Ideas', 'Publications', and 'People'. Below the header is a grid of images featuring various team members and project-related graphics. At the bottom, there are three featured content blocks: a TEDx talk titled 'A programming langu...', a 'Modeling Spacecraft' project, and 'The Julia Scientific Ecosystem'.

The screenshot shows the JuliaHub website homepage. The top navigation bar includes 'JuliaHub' and links for 'Platform', 'Pricing', 'Products', 'Industries', and 'Resources'. The main content area features a large graphic with a central purple ring and several icons representing features: 'MODELING & SIMULATION', 'SECURE ACCESS', 'TIME CAPSULE', 'INTEGRATED EDITING', 'TEAM COLLABORATION', and 'PACKAGE LIBRARY'. The headline reads 'Singular. Seamless. Streamlined for innovation.' Below this, a paragraph states: 'JuliaHub: a single platform for modeling, simulation, and user built applications. See how JuliaHub connects you with Julia's superpowers.' Two buttons are present: 'Create a JuliaHub Account' and 'Explore'.



Artificial Intelligence

The Turing Test

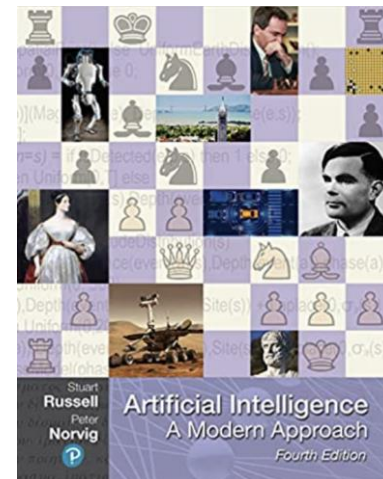


1950

Can you tell if you are chatting with a machine or a human?

What is intelligence?
*“intelligence is the rate at which a learner turns its **experience** and priors into **new skills** at **valuable** tasks that involve uncertainty and **adaptation**.”*

François Chollet, Google



Two aims:
Mimic humans vs
more rational?

Chat GPT: the AI Chat Bot in the news

AI Breakthrough: ChatGPT can almost pass US Medical Licensing Exam, study finds

Look What ChatGPT Did to My Online Dating Profile

'Once-in-a-lifetime opportunity': How one college professor is leaning into AI and ChatGPT

TECHNOLOGY EXECUTIVE COUNCIL

The ChatGPT AI hype cycle is peaking, but even tech skeptics don't expect a bust

PUBLISHED SAT, FEB 11 2023-11:10 AM EST | UPDATED SAT, FEB 11 2023-2:29

Some public school districts concerned about artificial intelligence tool ChatGPT and cheating

Chat GPT Urgent Warning: Is Your Information, Job or Business Safe?

essay, construct computer code, even compose songs given

Chat GPT: the AI Chat Bot in the news

AI Breakthrough: ChatGPT

can already
License

Look What ChatGPT Can Do for My

The New York Times

THE SHIFT

*Help, Bing Won't Stop Declaring Its
Love for Me*

A very strange conversation with the chatbot built into Microsoft's search engine left me deeply unsettled. Even frightened.

ality': How one
into AI and

TECHNOLOGY EXECUTIVE

The Ch
but eve
bust

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**Chat GPT Urgent Warning: Is Your
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Some examples of AI & ML In healthcare

- Scientific AI
 - new scientific discoveries
 - enhance understanding
- Natural Language Processing
 - patient chatbots
 - unify patient records
 - extract data
 - help patients
 - redact confidential information
- Precision Medicine
 - Custom treatments for the individual
- Computer Vision
 - detect tumors / lesions
- Physician Guidance

TIME

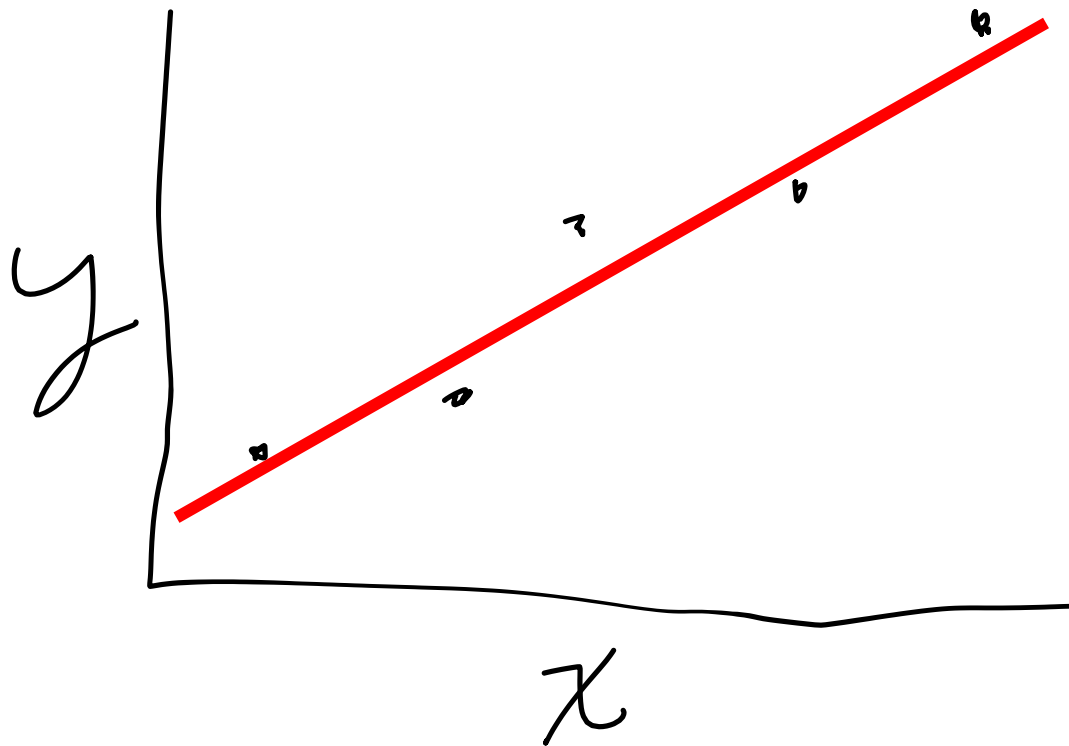
The AI Arms Race Is

Changing Everything

Proponents believe this is just the beginning: that generative AI will reorient the way we work and engage with the world, unlock creativity and scientific discoveries,

How does machine learning work?

Remember fitting a line to data?

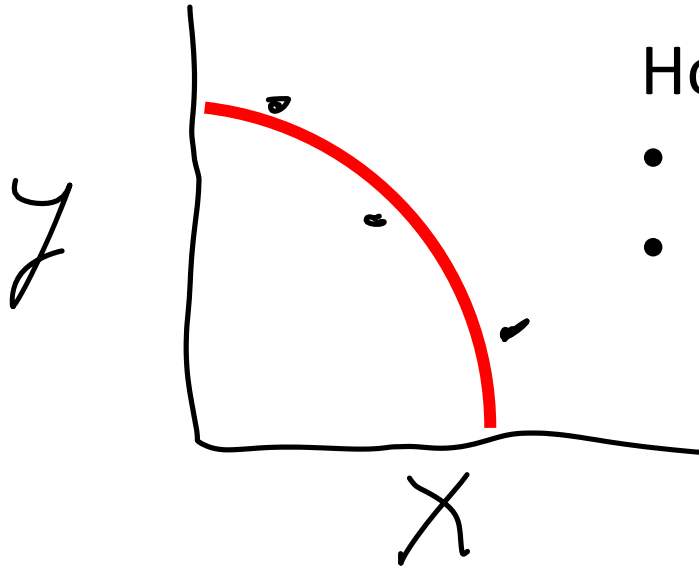


You had to find the “best” slope and intercept.

... only useful if the data naturally falls on a line.

How can you be more fancy?

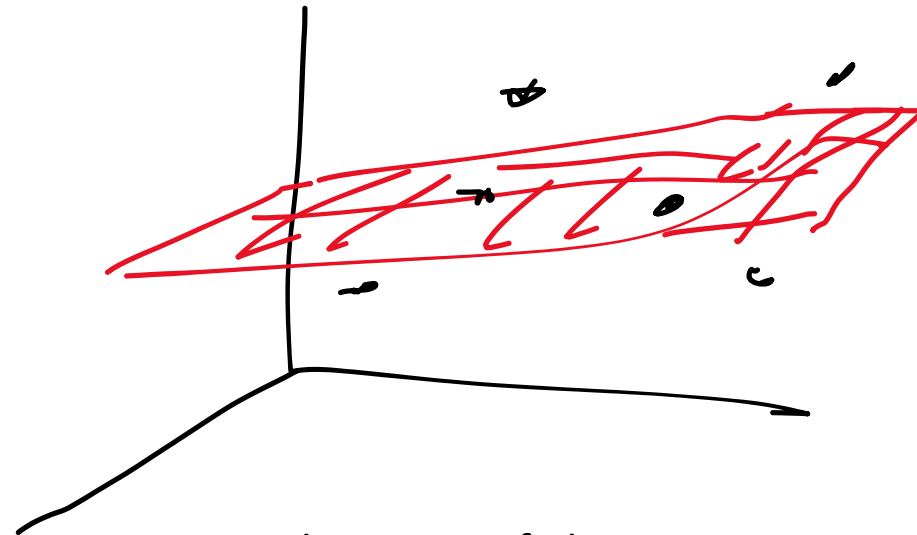
How does machine learning work?



Find Center and Radius

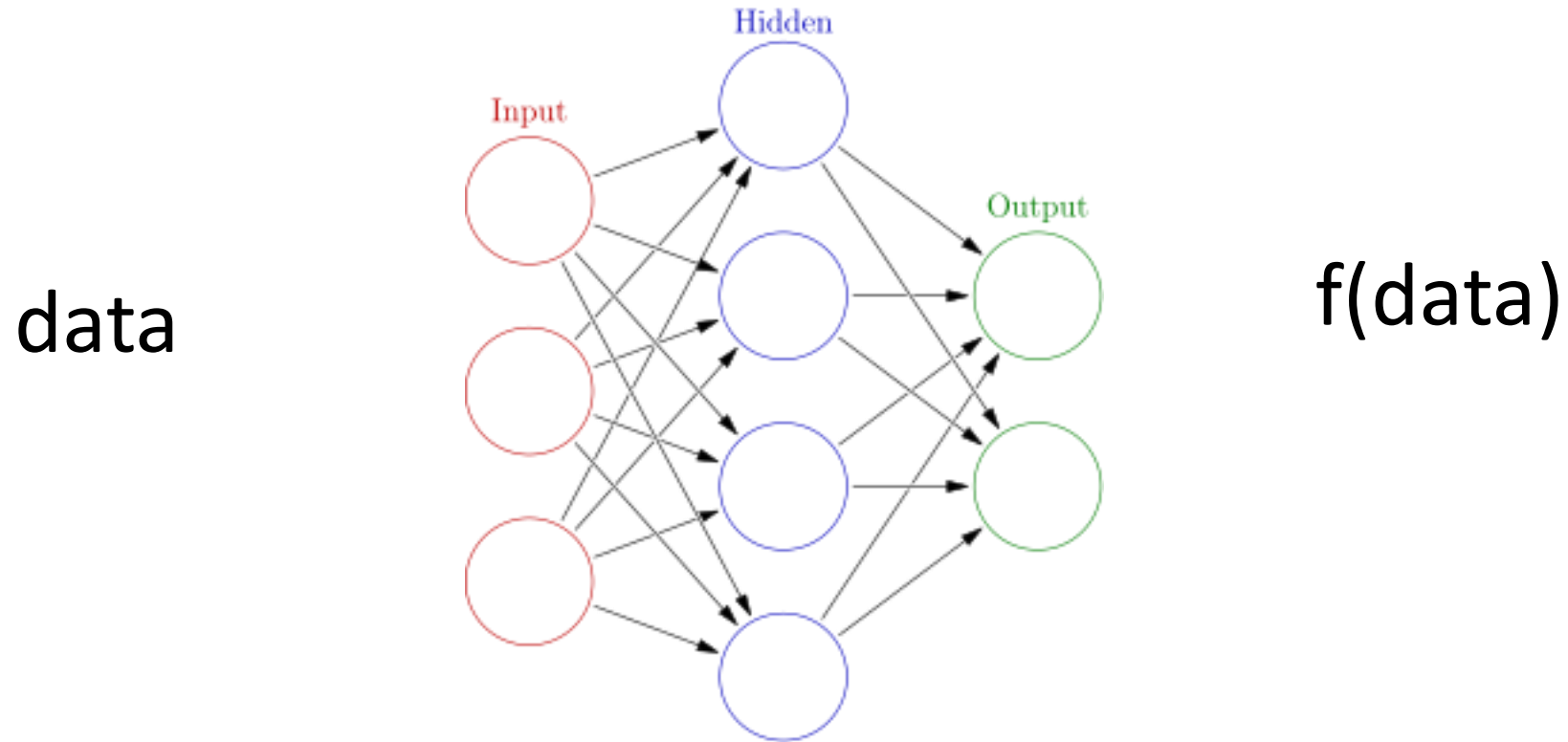
How can you be more fancy?

- Try using curves instead of lines?
- Add more variables?



Find Position of Plane

How does machine learning work?



parameters are learned to approximation $f(\text{data})$

Example: Apples and Bananas

- Suppose you have all kinds of apples, and you record various values such as the RGB coordinates of color, some numerical value of roundness. Label them with the number 1.
- Do the same for the bananas. Label with the number 2.



→ 1

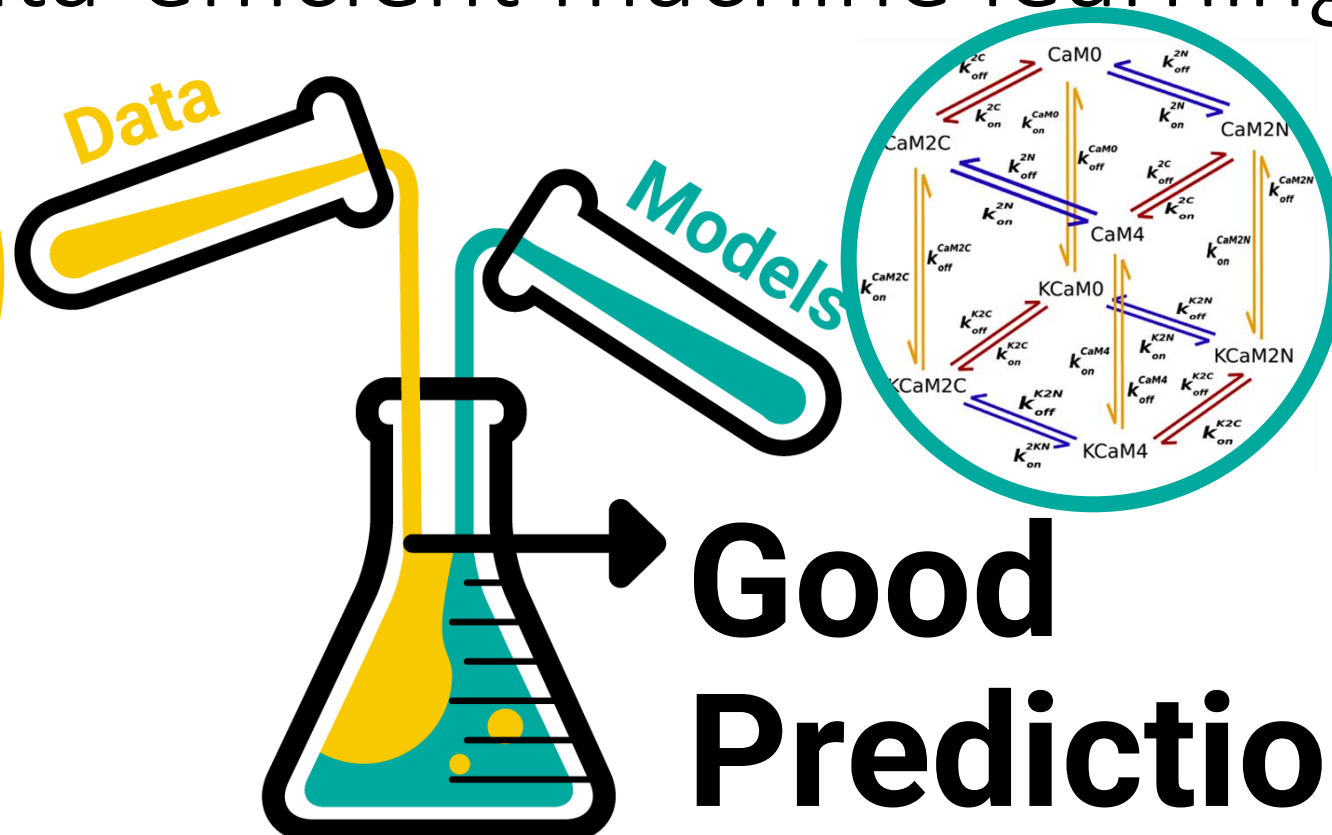
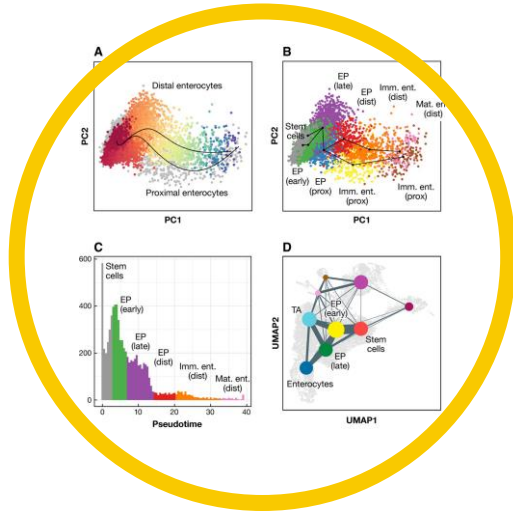



→ 2

A neural network will create a function that tries to match these and make predictions.

but what about science?

Scientific Machine Learning is model-based data-efficient machine learning



 Sci-ML ecosystem

How do we simultaneously use both sources of knowledge?

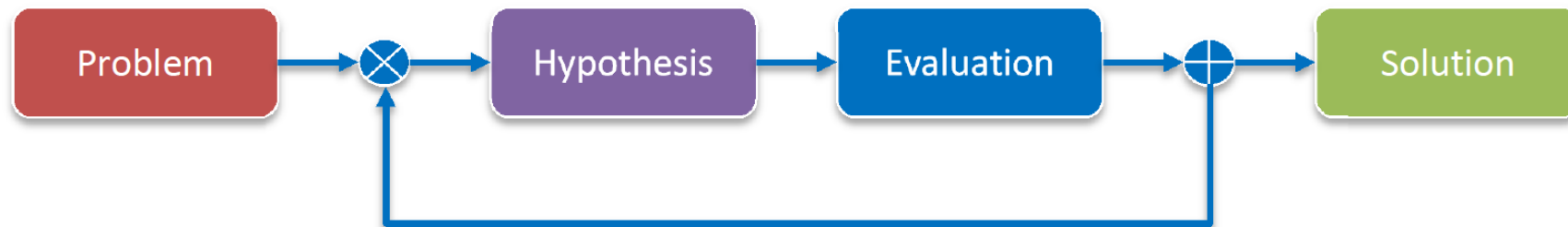
Technology
breakthrough for
science:

The next buzz for physical models
Differentiable Simulation:
What is it? What can it do?

(advanced machine learning at MIT)

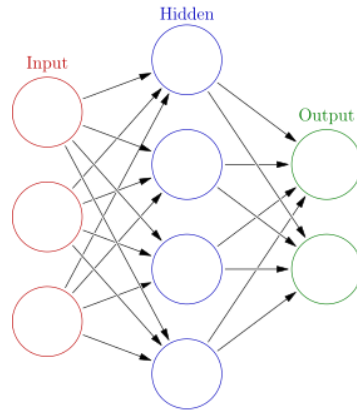
Advanced Machine Learning at MIT

- Current machine learning is often about big data
- We have made advances bring in human intuition, experience, and models.
- Approach: Replace the ignorant $h.(Wx+b)$ methodology with an encoding of human based models.
- Creation of Surrogate Models and insertion inside the neural network.

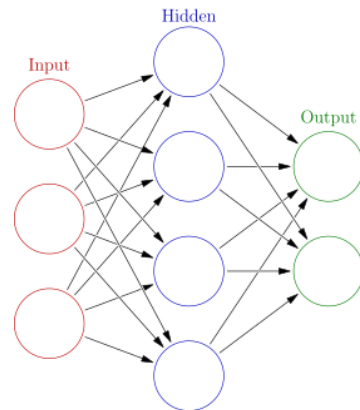


Universal (Approximator) Differential Equations

$$u' = f(u, \text{Hidden}, t)$$



$$\begin{aligned} x' &= \alpha x + \\ y' &= -\beta y + \end{aligned}$$



Rackauckas, Christopher, Yingbo Ma, Julius Martensen, Collin Warner, Kirill Zubov, Rohit Supekar, Dominic Skinner, Ali Ramadhan, and Alan Edelman. "Universal differential equations for scientific machine learning." *arXiv preprint arXiv:2001.04385* (2020).

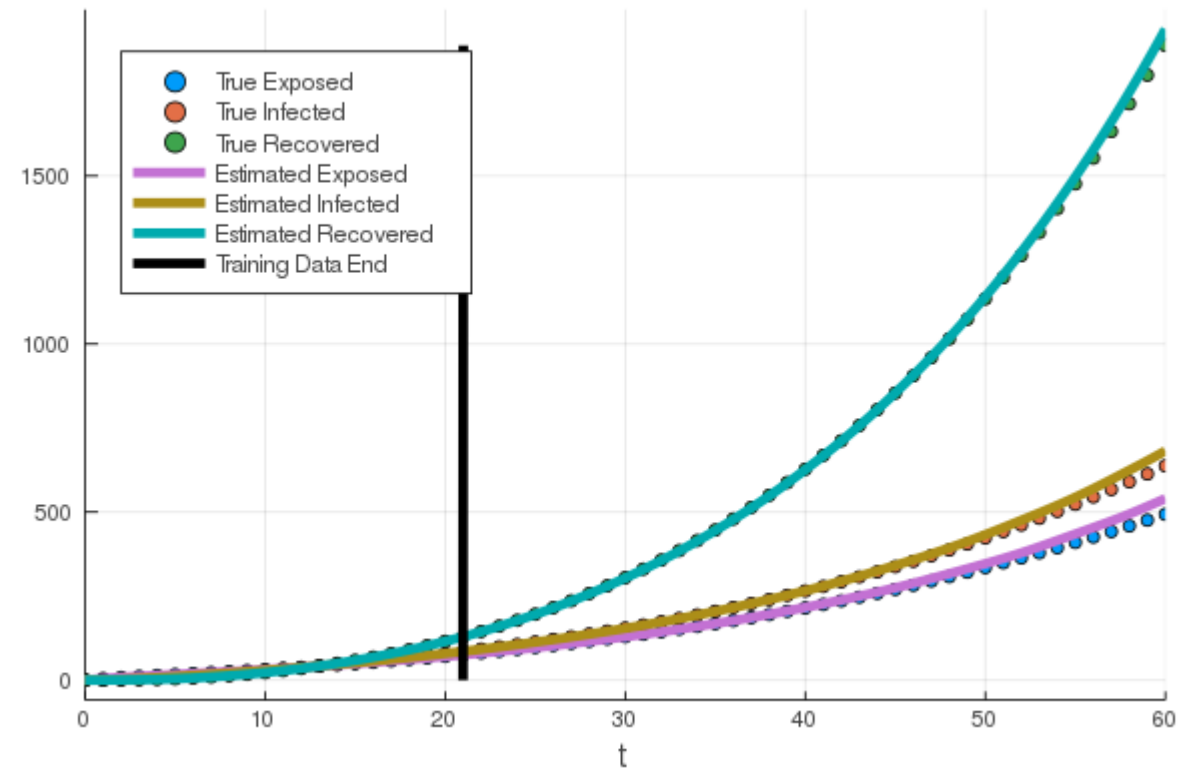
Universal ODE -> Internal Sparse Regression is the best

Sparse Identification on only the missing term

Operation[$u_2 * 0.10234428543435758 + u_1 * u_2 * 0.11371750552005416 + u_1^2 * u_2 * 0.12635459799855597$] of $u=(S/N, I, D/N)$

$$\begin{aligned}
 S' &= -\frac{\beta_0 S F}{N} - \text{Replace Unknown Portion} - \mu S, \\
 E' &= \frac{\beta_0 S F}{N} + \text{Replace Unknown Portion} - (\sigma + \mu) E, \\
 I' &= \sigma E - (\gamma + \mu) I, \\
 R' &= \gamma I - \mu R, \\
 N' &= -\mu N, \\
 D' &= d \gamma I - \lambda D, \quad \text{and} \\
 C' &= \sigma E,
 \end{aligned}$$

improves generalizability!



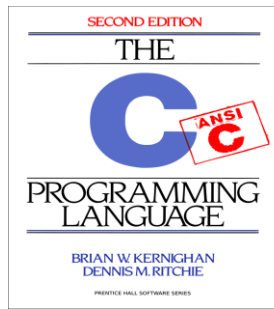
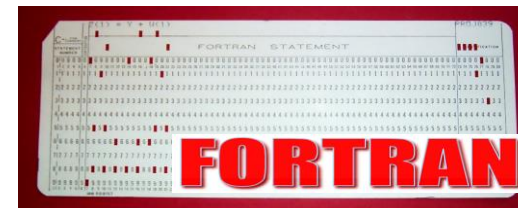
julia



Technology and smarts inside:
Multiple Dispatch
Type System
Composable Constructions
Abstractions, etc.



Directly wired
To c-calls



**We are not even close to the possibilities
of AI & ML.**