Accelerating Access to Life-Saving Treatments to Patients

pumas AI

Augmenting healthcare intelligence with predictive analytics that turn data into life-saving decisions

Our data-analytical tools help make data-driven decisions more efficiently

PumasCP
DeepPumas
Pumas
PumasQSP

We humanize technology to provide personalized treatments for patients

Lyv

Find the shortest development path for regulatory approval, with us

Scientific & Strategic Consulting

pumas AI

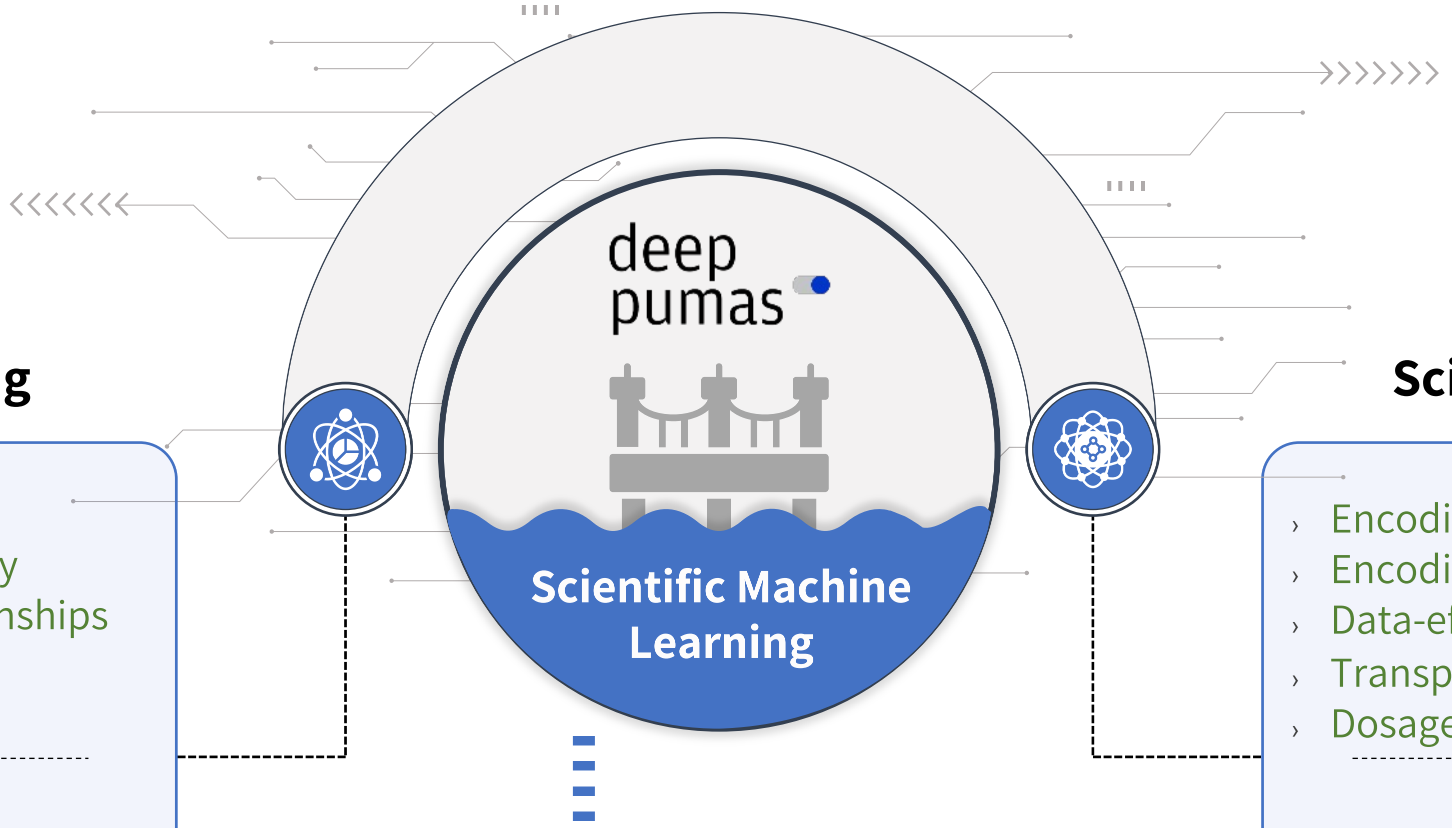
DeepPumas Introduction

Niklas Korsbo

Machine Learning

- Automatic model discovery
- Finding unintuitive relationships
- Handling complex data

- Lacks scientific understanding
- Requires big data
- Inscrutable



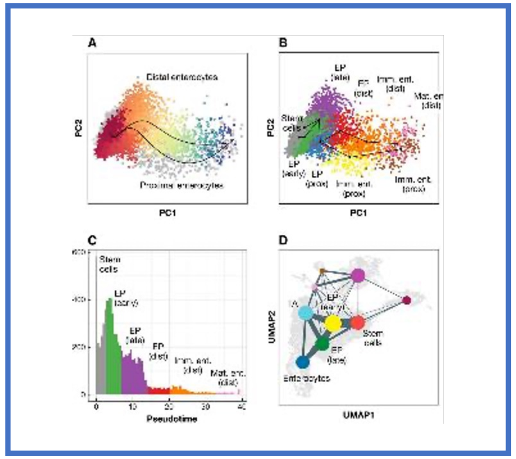
Scientific Modeling

- Encoding scientific understanding
- Encoding information hierarchies
- Data-efficient
- Transparent and interpretable
- Dosage optimization, etc.

- Labor intensive
- Misses unintuitive relationships
- Hard to utilize complex data

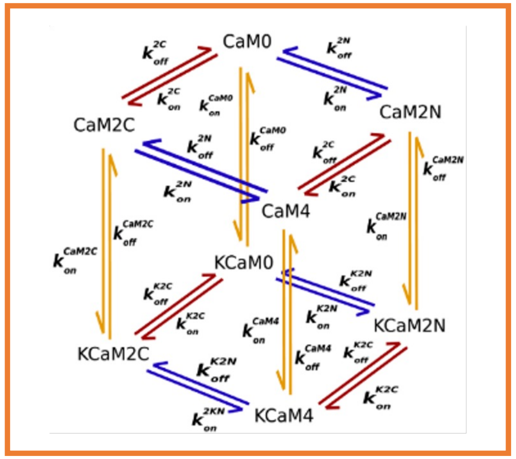
DeepPumas – simple and effective utilization of both knowledge and data

Data



Good Predictions

Models



Clinical Tests

Medical Images

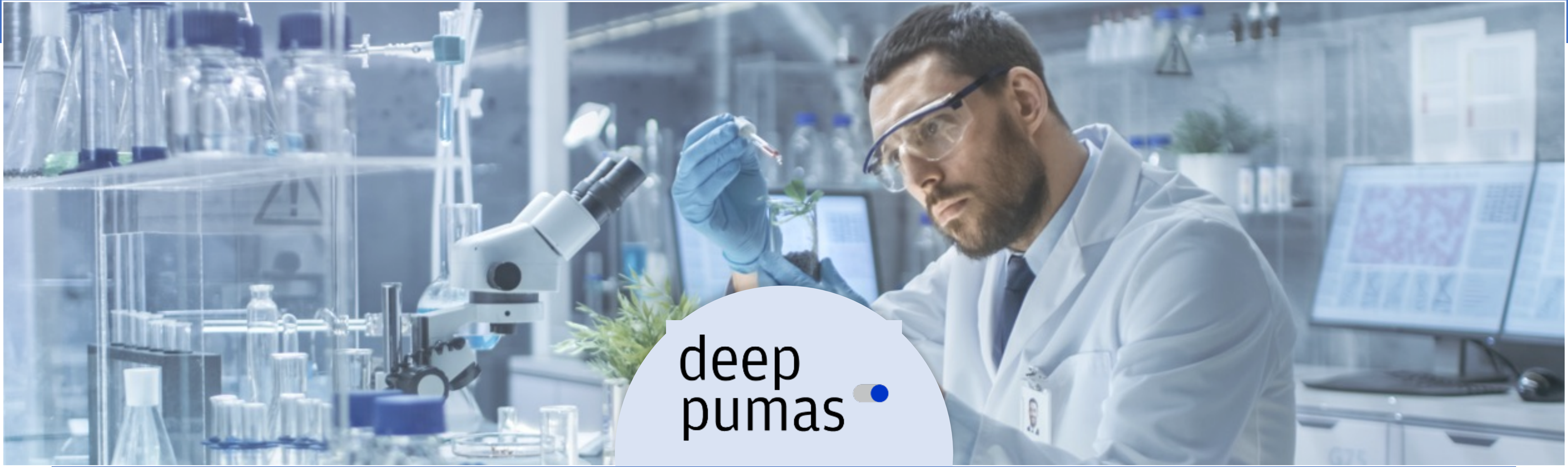
Measured Outcomes

Monitoring Devices

Omics

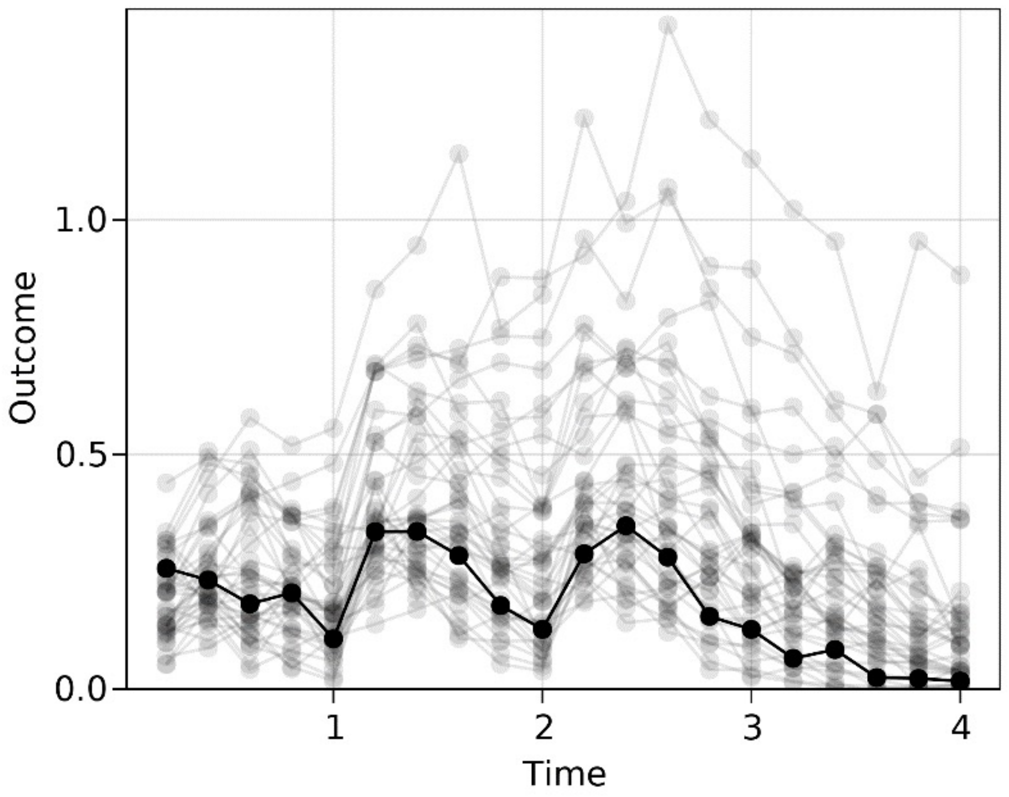
Wearables

- Known Molecular Interactions
- Known Cell Interactions
- Known Drug Properties
- Known Prognostic Factors



- Lead Generation
- Clinical Research
- Market Research
- Quality-by-design Manufacturing
- Individualized Patient Management

NLME



Typical values

$$\theta \in \mathbb{R}_+^3$$
$$\Omega \in \mathbb{R}_+^3$$

Patient data

Age
Weight

Random effects

$$\eta \sim \mathrm{MvNormal}\left(\Omega\right)$$

Individual parameters

$$\begin{aligned} Ka_i &= \theta_1 \cdot e^{\eta_{i,1}} + c_1 \cdot Age_i \\ CL_i &= \theta_2 \cdot e^{\eta_{i,2}} \\ V_i &= \theta_3 \cdot e^{\eta_{i,3}} + c_2 \cdot Weight_1^{c_3} \end{aligned}$$

Dynamics

$$\frac{d[\mathrm{Depot}]}{dt} = -Ka[\mathrm{Depot}],$$
$$\frac{d[\mathrm{Central}]}{dt} = Ka[\mathrm{Depot}] - \frac{CL}{V}[\mathrm{Central}].$$

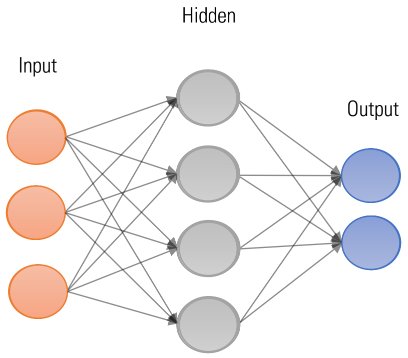
Error model

$$Outcome \sim \mathrm{Normal}\left(Central, \sqrt{Central} \cdot \sigma\right)$$

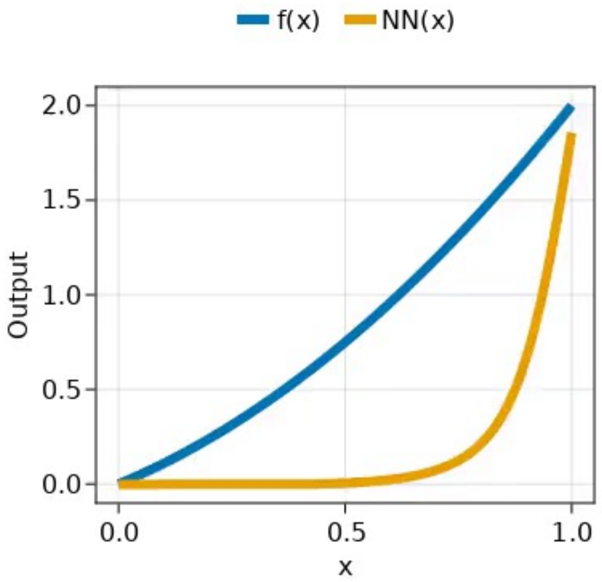
What is a neural network (NN)?

Information processing mechanism

Loosely based on neurons



Universal approximators!



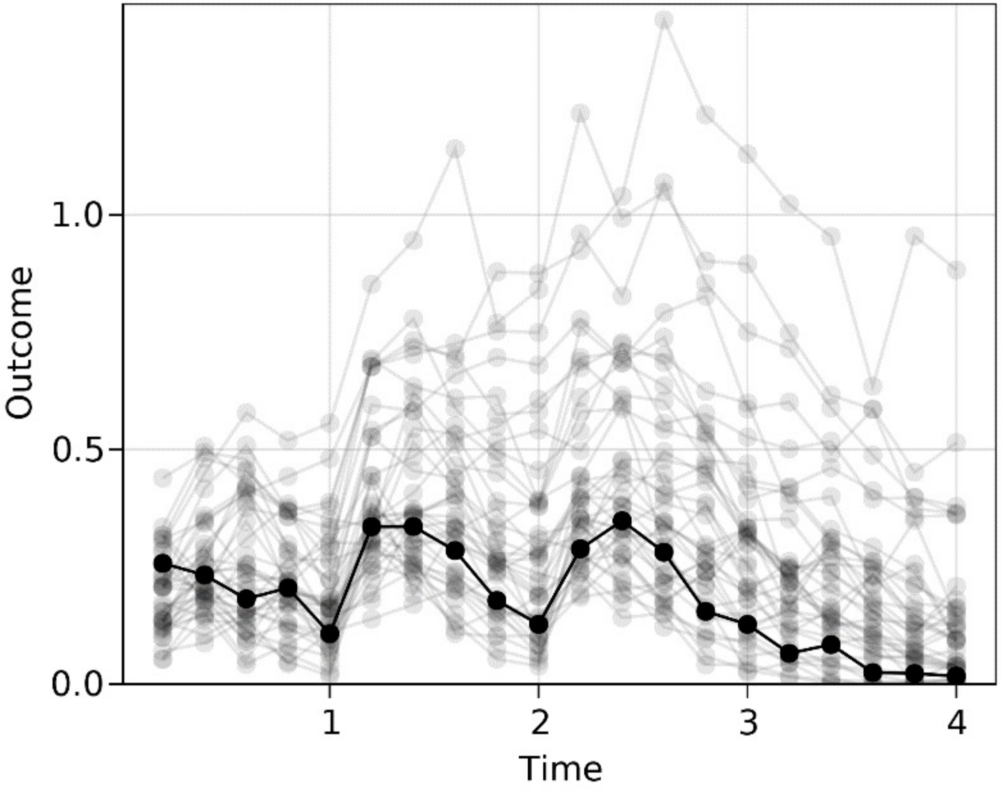
- Approximate <u>any</u> function
- Functional form tuned by parameters
- Parameter tuning can be linked to observed patient outcomes

Mathematically: Just a function!

NNs are useable anywhere where you'd use a function!

Use **data** to automatically discover **relationships**

NLME with DeepPumas



Typical values

$$\theta \in \mathbb{R}_+^3$$
$$\Omega \in \mathbb{R}_+^3$$

Patient data

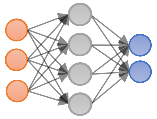
Age
Weight

Random effects

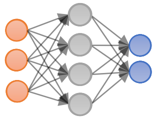
$$\eta \sim \mathrm{MvNormal}\left(\Omega\right)$$

Individual parameters

$$Ka_i = \theta_1 \cdot e^{\eta_{i,1}} + c_1 \cdot Age_i \quad +$$

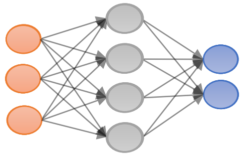


$$CL_i = \theta_2 \cdot e^{\eta_{i,2}}$$
$$V_i = \theta_3 \cdot e^{\eta_{i,3}} + c_2 \cdot Weight_1^{c_3} \quad +$$



Dynamics

$$\frac{d[\mathrm{Depot}]}{dt} = -Ka[\mathrm{Depot}],$$
$$\frac{d[\mathrm{Central}]}{dt} = Ka[\mathrm{Depot}] -$$

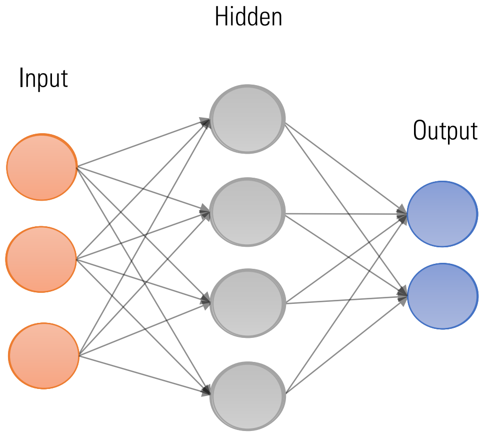


Error model

$$Outcome \sim \mathrm{Normal}\left(Central, \sqrt{Central} \cdot \sigma\right)$$

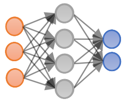
DeepNLME – Flexible local information processing

Covariate data
Dynamic variables
Random effects
Time
Drug PK



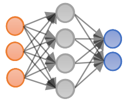
Individualized parameters
Outcome transformations
Longitudinal biomarkers
DiffEQ terms

Image



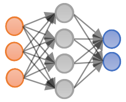
Parameter contribution

Time after first dose
Random effects



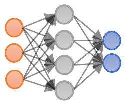
Individualizable longitudinal biomarkers

Receptor drug occupancy
Random effect

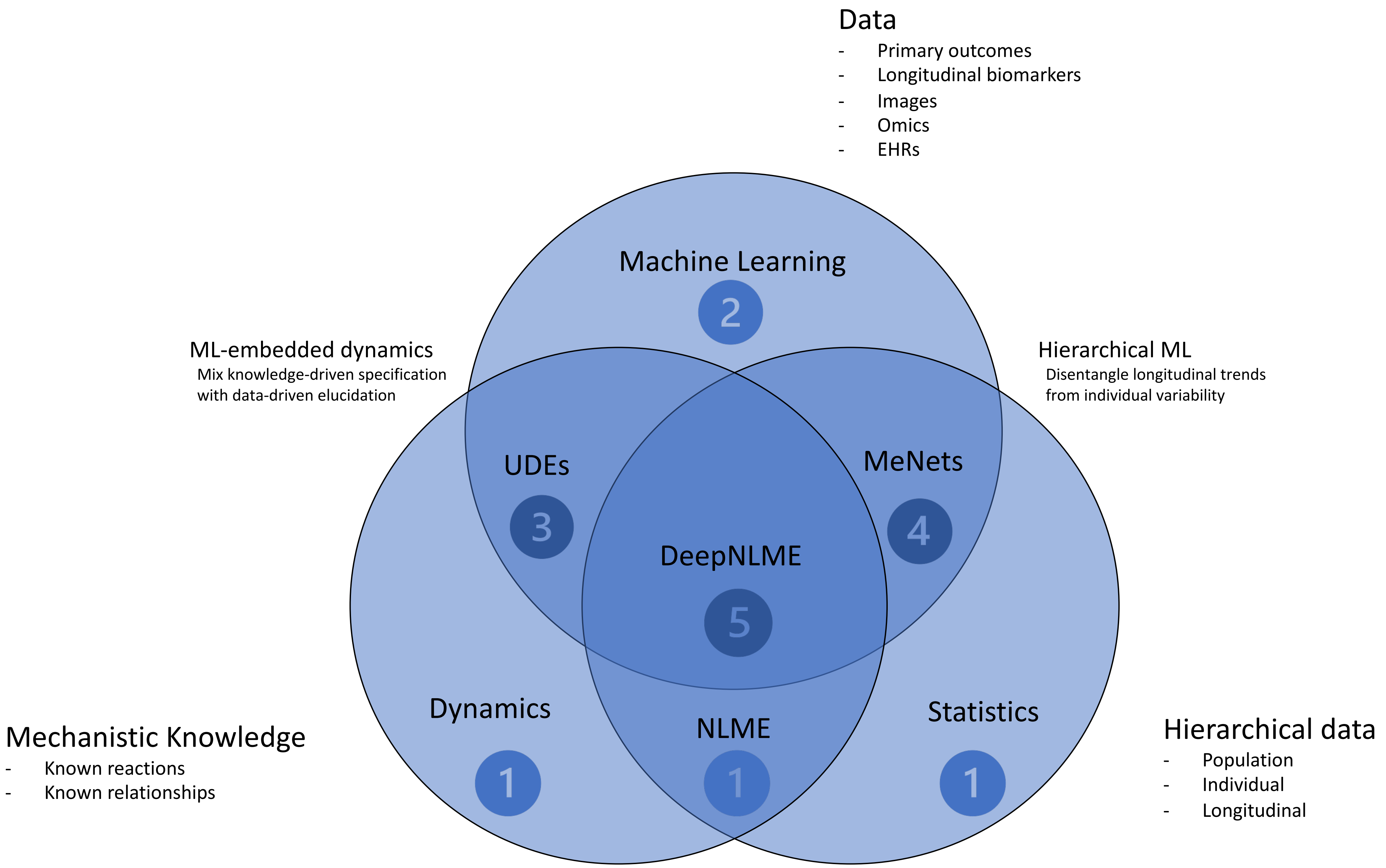


Pain score

Dynamic variables
Random effects



Individualizable dynamics term


Data
- Primary outcomes
- Longitudinal biomarkers
- Images
- Omics
- EHRs
Machine Learning
2
ML-embedded dynamics
Mix knowledge-driven specification
with data-driven elucidation
Hierarchical ML
Disentangle longitudinal trends
from individual variability
UDEs
3
MeNets
4
DeepNLME
5
Dynamics
1
NLME
1
Statistics
1
Mechanistic Knowledge
- Known reactions
- Known relationships
Hierarchical data
- Population
- Individual
- Longitudinal